

**VEGETATION DYNAMICS OF A GRASSLAND ECOSYSTEM
UNDER FOUR UTILIZATION PATTERNS**

THESIS

SUBMITTED TO THE FACULTY OF SCIENCE

BUNDELKHAND UNIVERSITY, JHANSI

**FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY**

**IN
BOTANY**



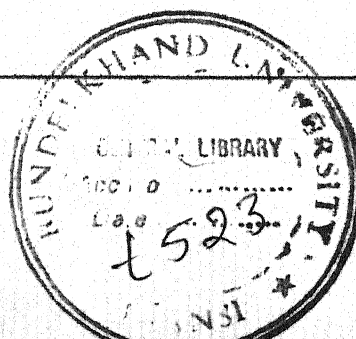
BY

DEVENDRA KUMAR PARASHAR

INDIAN GRASSLAND AND FODDER RESEARCH INSTITUTE,

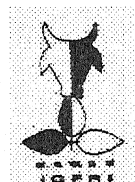
JHANSI - 284003

2002





INDIAN GRASSLAND AND FODDER RESEARCH INSTITUTE
JHANSI-GWALIOR ROAD, NEAR PAHUJ DAM
JHANSI-284 003, (U.P.), INDIA



DIVISION OF GRASSLAND AND SILVIPASTURE MANAGEMENT

Dr. B. K. Trivedi
M.Sc., Ph.D.
Principal Scientist & Ex-Head


Date- 11-11-2002

SUPERVISOR'S CERTIFICATE

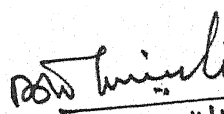
This is to certify that this work entitled "**Vegetation dynamics of a grassland ecosystem under four utilization patterns**" is an original piece of research work done by **Devendra Kumar Parashar**, M.Sc. (Botany) under my guidance for the degree of Doctor of Philosophy in Botany, of the Bundelkhand University, Jhansi (U.P.) India.

I further certify that:-

- (i) The thesis has been duly completed.
- (ii) It embodies the original work of the candidate himself.
- (iii) The thesis fulfills the requirements for the Ph.D. degree of the University.
- (iv) No part of the thesis has been submitted for any other degree or diploma.
- (v) It is up to required standards both in respect of its content and literary presentation for being referred to the examiners.


P. S. PATHAK
DIRECTOR

Indian Grassland And Fodder
Research Institute, Jhansi-284003


(B. K. Trivedi) 11/11/02
Supervisor

DECLARATION

I hereby declare that the thesis entitled "*Vegetation dynamics of a grassland ecosystem under four utilization patterns*" being submitted by me for the award of the degree of Doctor of Philosophy in Botany, Faculty of Science, Bundelkhand University, Jhansi (U.P.) is an original piece of research work done by me and is not substantially the same as one which has already been submitted for degree or any other academic qualification at any other University.

Date- 11-11-02



(D. K. PARASHAR)

ACKNOWLEDGEMENTS

I deem it to be a great pleasure to express my esteemed gratitude to Dr. B.K.Trivedi, Principal Scientist and Ex-Head, Grassland and Silviculture Management Division, Indian Grassland and Fodder Research Institute, Jhansi for his inspiring guidance, enestimable help for this investigation. I am sure that due to his continuous guidance all my work was successfully completed.

I express my deep sense of gratitude to The Director, Indian Grassland and Fodder Research Institute, Jhansi for providing me all facilities during the tenure of my research work.

I gratefully acknowledge to Dr. V.C.Pachori, PS & Ex Co-ordinator, NCP on Crop Based Animal Production Systems, Dr. S.S.Kundu, PS & Head, PAR Division and Dr. N.C.Verma, PS & I/C NCP Centre, IGFR, Jhansi for his valuable advise, suggestions and providing me all laboratory facilities during the course of investigation when ever needed.

I am also grateful to Dr. Vinod Shankar, PS & Ex-head, Division GSM, Dr. M.M. Roy, PS & Head, Division, GSM, Dr. J. N. Gupta, PS, Dr. N. P. Shukla PS, Dr. R. K. Bhatt Sr. Sci, Dr. T.A. Khan Sr.S, Dr. J. P. Singh Sr.S (Geo) and Dr. J.P. Singh Sr.S (Eco.Botany) for their valuable help, encouragement and suggestions in my research work.

I wish to extend my grateful thanks to Dr. R.B. Yadav, Sr.S (Soil Science) in soil analytical work, Dr. A.B. Mojumdar, PS, Dr. G.H. Pailon, Scientist (Animal nutrition), Dr. Sultan Singh, SS, Dr. S.K. Mahanta, SS for the help received in forage chemical analytical work during study.

Thanks are also due to Dr. H. S. Tiwari, RA, Dr. Vinod Kumar SRF, Sri Laxminarayan T-4, Mr. Mukesh Kumar SRF and supporting staff for their help in field experiment and laboratory work during the course of investigation. Assistance provided by Mr. Ajay kumar Gour, Mr. Prem Chandra and Mr. Dhiraj Dhingra T-2 also acknowledged.

I cannot express my feelings towards my parents, brothers and family members for their help, encouragement and moral support. Encouragement and support rendered by my wife Mrs Seema Parashar cannot be expressed. At last I express my cordial thanks to my all friends for all round support.

Finally, the financial assistance during the course of investigation provided by Indian Council of Agriculture Research, New Delhi is also acknowledged.



DATE

11-11-02

(DEVENDRA KUMAR PARASHAR)

LIST OF TABLES

Table No.	Title	Page No.
1	Meteorological data at C R Farm IGFRI, Jhansi during study period	27
2	Physical and chemical characteristics of soil in different systems	31
3	Soil moisture (%) for growth and post growth period in different systems	34
4	Species diversity of different systems	39
5	List of species found in different grazing systems	41
6	Relative dominance of different species under four grazing systems	43
7	Relative composition of different species under four grazing systems	44
8	Relative frequency of different species under four grazing systems	45
9	IVI of different species under four grazing systems	46
10	Plant vigour of range grasses in different systems (1998)	48
11	Plant vigour of range grasses in different systems (1999)	49
12	Plant vigour of range legumes in different systems (1998)	51
13	Plant vigour of range legumes in different systems (1999)	52
14	Species wise dry forage production (g/m ²) in different systems	54
15a	Dry forage production (t/ha) of species groups for growth period in different systems	55
15b	Total dry forage production (t/ha) for growth period	55
16a	Dry forage production (t/ha) of species groups for post growth period in different systems	61
16b	Total dry forage production (t/ha) for post growth period	61
17	Average density (plants/ha) of woody species in different systems	64
18	Growth parameters of woody species in different systems	66
19	Top feed production (kg/ha) of woody species in different systems	68
20	Fuel wood production (q/ha) of woody species in different systems	71
21	Fuel wood & top feed production of trees and shrubs in different systems	73
22	Chemical composition of forage during growth and post growth period in different systems	75
23	Average body weight (kg/hd) of sheep, goat and cow in different systems	80

LIST OF FIGURES

Figure No.	Title	Page No.
1	Meteorological data at C R Farm IGFR, Jhansi	28
2	pH value in different grazing systems	32
3	Soil moisture (%) in different grazing systems	32
4	Organic carbon (%) in different grazing systems	35
5	Available nitrogen (kg/ha) in different grazing systems	35
6	Available phosphorus (kg/ha) in different grazing systems	36
7	Available potassium (kg/ha) in different grazing systems	36
8	Species diversity in different grazing systems	40
9	Biomass of perennial and annual grasses in different grazing systems	56
10	Biomass of legumes and forbs in different grazing systems	57
11	Litter biomass in different grazing systems	58
12	Dry forage production in different grazing systems during growth period	59
13	Biomass of species groups in different grazing systems during post growth period	62
14	Dry forage production in different grazing systems during post growth period	62
15	Total top feed production in different grazing systems	69
16	Fuel wood production of trees in different grazing systems	72
17	Fuel wood production of shrubs in different grazing systems	72
18	Total fuel wood production in different grazing systems	72
19	Dry matter (%) in different grazing systems	76
20	Neutral detergent fibre (%) in different grazing systems	77
21	Crude protein (%) in different grazing systems	77
22	Acid detergent lignin (%) in different grazing systems	78
23	Acid detergent fibre (%) in different grazing systems	78
24	Body weight of sheep in different grazing systems (1998)	81
25	Body weight of sheep in different grazing systems (1999)	81
26	Body weight of goat in different grazing systems (1998)	82
27	Body weight of goat in different grazing systems (1999)	82
28	Body weight of cow in different grazing systems (1998)	83
29	Body weight of cow in different grazing systems (1999)	83

LIST OF PLATES

Plate No.	Title	After Page No.
I	Study site with the lay out of the experiment	17
II	Mixed herd grazing in rotational grazing system plot	17
III	Data recording of botanical composition of grassland through line interception method	42
IV	Measuring of vigour attributes of range grasses in grassland	42
V	Lay out of Quadrate for estimation of forage biomass	53
VI	Sorted samples of clipped material of species and species groups for biomass	53
VII	The growth performance of range species during post growth period	60
VIII	Grazing during post growth period in continuous system	60
IX	Stall feeding of cattle (cut & carry system)	79
X	Stall feeding by small ruminant (sheep & goats) in cut and carry system	79

CONTENTS

CHAPTERS	Page No.
Supervisor's certificate	
Candidate declaration	I
Acknowledgement	II
List of tables	III
List of figures	IV
List of plates	V
Chapter-1 Introduction	1-3
Chapter-2 Review of Literature	4-16
Chapter-3 Materials and Methods	17-25
Chapter-4 Results	26-83
I. Climate study	
II. Soil study	
III. Plant study	
IV. Animal study	
Chapter-5 Discussion	84-96
Chapter-6 Summary and Conclusion	97-102
Bibliography	103-121
Appendix	122-123

CHAPTER - 1

INTRODUCTION

The domestication of livestock in India is second most important occupation, only next to agriculture. India contributes 15% of world livestock population while it has only 2% (326.8 mha) of world geographical area. The total utilizable area of 301 mha is further devoted to arable lands 51 percent, forests 16 percent, permanent pastures 4 percent and other grazing lands and uncultivable degraded lands constitute an area of 29 percent. Even if nonagricultural land is included, the total area under grazing lands works out to 85.5 million ha. This is the area which supports India's livestock population, in addition to a proportion of agriculture crops which are fed to the livestock. Hence the total area of grazing lands in India is 100.3 mha.

The grazinglands, pasture and forests are major forage resources for the livestock in our country but these resources are over utilized. A rough estimate shows that grassland and forests together contribute to about 40% of the present forage supply position and the remaining 60% of the forage supply comes from the fodder crops, agrowastes and crop residues. The cultivated lands are already under tremendous pressure of food crops cultivation in order to feed the growing human population and hence, there

is no scope of increase in the area under forage crop production. Moreover, the cultivation of fodder crops is meager mainly due to the lack of irrigation facilities. Availability of crop residues is also insufficient as most of the cultivated area is rainfed and single cropped. The cropped area under fodder production is about 8.3 million ha. (4.4%). It is difficult to maintain a huge livestock population due to low level of biomass production from degraded grasslands.

In general the grazing intensity in our country is very high i.e. 2.6 ACU/ha as against 0.8 ACU/ha in developed countries and in semi-arid region it is very high viz., 4.72 ACU/ha. The number of bovines per hectare is very high which results in to compaction of soil, decrease in production and nutritive value of natural grazing lands, add to this is the fact that ecosystem is disturbed. Due to disturbance in ecosystem the geology, soil and plant stability is also disturbed leading to change in the flora, fauna, hydrological relation and soil biological systems. The losses in physical and nutritionally lost fertility status of soil are so high that it may take several years to recoup.

Restoration of ecosystem is of paramount importance; one of the steps to restore it is protection of habitats and communities from further deterioration and losing of the extinct species of vegetation. The present availability of livestock grazing resource can significantly be improved by adopting the improved technology specially renovation of grazing areas to improve pasture, grazing lands which supply biomass manifold (depending up on soil, rainfall, climate etc.). Low biomass and poor nutrition of present grazing lands is due to heavy grazing pressure per unit area and disappearance of potential species of grasses, legumes, shrubs and trees. To overcome this problems, the scientists at Indian Grassland and Fodder Research Institute, Jhansi have developed various technologies relating to grassland management, livestock improvement and varietal development of fodder crops. Application of the improved technologies of soil conservation, vegetative sustenance, grazing management to utilize the biomass efficiently and economics of system has resulted into overall improvement and ultimately more return from degraded lands. Keeping above in view the present study entitled "Vegetation dynamics of a grassland ecosystem under four utilization patterns" was planned with the aim to identify the appropriate utilization system for maintaining these grasslands as sustainable production unit.

Considerable works have been carried out on the structure and productivity of these grasslands while the studies are meager on their utilization. The present study is a part of the project on grassland based animal production at Indian Grassland and Fodder Research institute, Jhansi. In 1986, it was felt that animal grazing was responsible for deforestation and environmental degradation in the ecologically fragile areas, which, however, could not be authentically substantiated by the Task Force Committee of GOI because of lack of critical research data. It was a general feeling that in the ecologically fragile zones of country, specially in Bundelkhand region being semi-arid, livestock grazing particularly sheep and goat in large number is mainly responsible for deterioration of grassland ecosystem causing environmental degradation. So in the 4th Regional Committee Meeting of Indian Council of Agriculture Research in 1986, it was decided that a collaborative research programme on various aspects of forage and fuel production, livestock feeding and their economical impact should be developed by Indian Grassland and Fodder Research Institute, Jhansi.

In the first phase (1987-92) of the project the four forage production systems viz. three tier, sown pasture, improved pasture and natural grassland were evaluated for plant, nutrient loss in soil, animal, water run off and economic components. At the end of first phase improved pasture was found best. In the second phase, keeping the production system i.e. improved pasture as a constant, four grassland utilization systems viz., rotational, deferred rotational, continuous and cut & carry (no grazing) were evaluated ultimately to find out sustainable utilization system. Accordingly the present study was initiated with an aim to find out the best system of grassland utilization for sustainable production.

CHAPTER - 2

REVIEW OF LITERATURE

In ecologically fragile zone of country especially in Bundelkhand region of Central India, Rajasthan desert, saline area of Mathura and in the Himalayan region livestock grazing in on large scale (many times more than its carrying capacity) which is mainly responsible for environmental degradation causing soil erosion, soluble nutrients loss and deterioration of grassland ecosystem. The problem of grazing has further aggravated because large area of village grazing lands and forests has been brought under plough although it is not suitable for crop production. Dalal, (1992) realized the need for developing an ideal three-dimensional ecosystem of soil-plant-animal system under scientific management for optimum productivity and sustainability. Such a man made ecosystem covers three principal items: land and microclimate amelioration; animal feed, fuel wood, timber and occasional production of cash crops.

In the recent years much emphasis is being laid on farming system research involving multidisciplinary approaches to tackle the problems of farmers on clientele basis. To critically assess the resources depletion and soil degradation through soil and water losses, nutrients and vegetation losses from the degraded grazing lands, due to livestock grazing from renovated, improved and natural wasteland area an inter-institutional collaborative project on crop-livestock farming system research was undertaken. It was simultaneously started at Indian Grassland and Fodder Research Institute, Jhansi, Central Sheep and Wool Research Institute, Avikanagar near Jaipur, Central

Institute for Research on Goat, Makhdoom (Mathura), Central Arid Zone Research Institute, Jodhpur, Central Sheep and Wool Research Center, Pashulok, Bharari sein and Munseyari at high hills from 1987. Work done between 1987-92 resulted for increasing forage livestock production on sustainable basis on one hand and production resource built up on the others. The result of this study helped millions of landless animal grazers and poor farmers to increase livestock production without destruction of base resource. But in 1992, it was felt that the productivity of the grasslands, however, decreased progressively due to grazing and hence most suitable grazing management system was needed to be developed for sustainable productivity. Based on this consideration a multidisciplinary Network Collaborative Programme on Crop Based Animal Production System was started by ICAR with five other research institutes i.e. IGFRI, Jhansi, CIRG, Makhdoom (mathura), CSWRI, Avikanagar (Raj.), National Research Center on Camel, Bikaner and Indian Veterinary Research Institute, Mukteshwar campus. The present state of knowledge related with this study is divided in the following texts:

I. Climate

Climate is one of the principal environmental factor which influences the interaction of biological organisms and impose many of the primary tolerance limits in the selection of the species capable of surviving in a given area. The various microclimatic factors like air temperature, soil temperature, soil type, relative humidity, wind velocity, tree canopy and distribution of rainfall are of great importance in the grassland system which decide the suitability of a particular crop or grass to be introduced.

Ullah *et. al.*, (1972) evaluated the effect of contour furrows and contour bunds on water conservation in grassland of Western Rajasthan and found that the contour furrowing and bunding treatments increased in forage yield and moisture percentage. Prajapati *et. al.*, (1975) reported ecological studies on village grazing lands representing two-soil types viz., heavy and medium soil under four intensities of grazing (protected, moderate, heavy and very heavy grazing) and reported that unsystematic and continuous

grazing resulted into retrogression of pastures under all magnitudes of grazing stresses on both soil types.

Singh *et. al.*, (1980) assessed the effect of tree shade (full shade, partial shade and open area) on forage yield in grassland planted with *Acacia catechu* and *Dalbergia sissoo* in north India. They noticed that forage yield was significantly higher in open than under partial shade or full shade. Harsh *et.al.*, (1981) found the relationship between precipitation and forage production of *Cenchrus ciliaris* in arid region.

Misra and Bhatt (1990) studied interaction of infiltrated light and canopy temperature on the productivity of grasses viz., *S. nervosum* and *H. contortus* under the tree canopies of *Hardwickia binata*, *Leucaena leucocephala*, *Acacia tortilis*, *Albizia lebbek* and *A. amara*. Ramakrishna (1984) studied the microclimatic variations around the tree cover under 13 years old *A. tortilis* based silvipastoral system. Rao *et.al.*, (1993) reported that during low rainfall years *C. ciliaris* produced higher dry matter yield, water and energy use efficiency than *C.setigerus* where as under high rainfall *C.setigerus* performed better than *C. ciliaris*.

Shukla (1996) studied the water logging and fodder production at IGFRI, Jhansi in semi-arid region of India and found that *Brachiaria mutica* was the best species for water logged conditions. Among leguminous, *Sesbania sesban* could be grown on bunds and sun hemp was another crop for excess moisture condition. Under shallow water *Trifolium*, *Medicago denticulate*, *Pisum sativum* and *Lathyrus sativa* produced maximum yield and resulted in higher water use efficiency.

II. Soil Study

The grazing brings about changes in vegetation composition as well as physical and chemical factors in the soil. Several workers worked on the physical and chemical structure of soils. Sant (1966) studied the effect of grazing on grassland soils of Varanasi India under protected and grazed area and reported that the moisture content, organic matter showed higher value in the protected field as compared with grazed field. Dymess

and Youngberg (1966) reported the relationship between soil-vegetation with in Pondura pine type in the Central Oregon pumice region.

Dee *et.al.*, (1966) found that grass vegetation influences the water intake of clay loam soil. Laycock and Conrad (1967) evaluated the effect of grazing on soil compaction at high elevation cattle range. Bulk density of soil in grazed and ungrazed plots was similar and increase in the bulk density in summer both in grazed and ungrazed areas was attributed to change in soil moisture. Brockman *et. al.*, (1971) studied the effect of grazing animals on the nitrogen status of grass swards and concluded that nitrogen increased grass yield more on grazed swards than in cut swards and this effect was greatest on soils with high available soil nitrogen.

A study by Strogen *et. al.*, (1979) on litter fall from shrubs in USA with biweekly to monthly intervals collection as leaves, stems, flowers and fruits separately showed that leaves were generally the largest litter category, followed by stems, fruits and flowers. Vossbrinct *et.al.*, (1979) reported the abiotic and biotic factors in litter decomposition in semiarid grassland and found that higher grass litter was decomposed in the microbial and lower litter has disappeared from the abiotic treatments. Omaliko (1984) studied the dung decomposition and its effect on soil components of a tropical grassland ecosystem and reported that the available soil nitrogen and phosphorus increased significantly in the top 5 cms layer of soil in the first week.

Raina and Joshi (1991) observed that the sown pastures maintained higher nutrient status of soil especially with ungrazed situation while natural pasture had indicated a low nutrient status. Hazra (1995) assessed the grasses and legumes for soil and water conservation in semiarid tropics of India and observed that *Cenchrus*, *Pennisetum* and *Dichanthium* species are good soil binders which provide good cover and reduce soil loss.

III. Plant study

Botanical Composition

Oosting (1958) reported that the grasses of a particular climax are adapted to its climate and usually have an advantage in term of composition over introduced ones. Wheeler (1958) investigated the effect of sheep extract and nitrogen fertilizer on the

botanical composition of Rye grass/ white clover and found that applied nitrogen and urine were the dominant factors affected botanical composition. Studies conducted on long grazing by Hyder *et.al.*, (1966) on botanical composition during 23 years at different intensities reported that most important effect of heavy grazing has been a reduction in herbage yield. Hazel (1967) observed that no correlation was noticed between grazing intensities and basal cover; but heavy grazing caused an increase in number of undesirable grasses and forbs.

Chinnamani (1969) evaluated the species dynamics of natural grassland of red soil of Hyderabad and found that *H. contortus* was replaced by *Chrysopogon* in dry places and *Eremopogon* in moist locations. Thus within 7 to 12 years the colonies were completed replaced by *S. nervosum* in dry places and pure patches of *Chrysopogon* and *Eremopogon* and burnt areas with *Cymbopogon* occupy moist pockets. Thus study revealed that any bare area could be converted into a *Sehima* sub type of grassland.

Sharitz and Mccormik (1973) studied the population dynamics of two competing annual plant species including density, distribution, biomass, seed production and survival and reported that the population dynamics of dominant out crop species are primarily influenced by interspecific competition for soil moisture in habitats of varying soil depth. Paulsamy *et. al.*, (1987) studied the effect of over grazing on the phytosociology of a tropical grassland in Western ghats over a period of one year with protected and grazed sites. This study revealed that both protected and grazed sites have equal number of species with different floristic composition and intense grazing destroyed a few palatable annuals. The over grazing favored annuals into the grassland if unchecked.

Melkania (1988) reported the floristic composition and life forms of vegetation in Central Himalayan under natural mixed broad leaf forest and found that the number of annual species were maximum in all the habitats during rainy season but perennial species were recorded to survive because of stored moisture in the soil during later part of the year.

The studies on species composition of a protected and grazed plot of Savanna in a dry tropical forest by Pandey (1990) indicated that grazing increased the annual, perennial grasses, legumes and other forbs. Shah and Saxena (1990) estimated the

variation in structure; biomass and species diversity of grazing lands in Garhwal Himalaya under *Quercus leucotrichophora* forest, *Pinus roxburghii* forest and two open grasslands. Diversity showed a positive relation with the dry matter yield, whereas the relationship between the concentration of dominance and yield was negative. Similarly, Chaturvedi and Saxena (1992) determined the composition, yield and diversity of grazing lands under Chir Pine forest in Central Himalayas and found that contribution of grasses to the total herbaceous yield was higher as compared to leguminous and non-leguminous forbs. The diversity increased with decreasing yield of grasses, while the relationship between diversity and yield of forbs was positive.

Trivedi (1994) observed the seasonal variation in composition of grassland communities district of Jhansi in the Bundelkhand region. Results revealed that in natural grassland the number of species were more in November and least in month of May. Pandit *et. al.*, (1996) investigated the species composition and lifeforms of the grazing land at Bhavnagar under protected and unprotected and observed that the maximum density of individual species was observed in August and most of species perished by the end of winter season in both treatments. Rai (1997) reported the impact of grazing on the plant composition in natural grassland and established silvipasture and found that legume component is affected severely by grazing in both the types of pastures. Trivedi and Soam (1998) assessed the botanical composition in Shivpuri National Park and reported *Heteropogon-Eragrostis-Sehima* community. Among vegetation *H. contortus* was dominant.

Biomass

Horrell and Court (1965) studied the effect of the legume *Stylosanthes gracilis* on pasture yield at Uganda and observed that in a mixture of *Chloris gayana* and *S. gracilis* when fertilized with phosphorus and sulphur, the yield of mixed pasture was over three times as much as the pure grass but the legume component of the mixture depressed the grass component as a result of competition. Taintan (1974) determined the effect of different grazing rotation on pasture production and found that the rate of leaf growth declined 3 to 5 weeks after grazing, depending on treatment and season. Pinder (1975) studied the effect of species removal on an old field plant community and observed that

removing of dominant grasses increased the net productivity of subordinate forb species as compared of the unaltered community.

Debroy *et al.*, (1975) studied the intensities and interval of defoliation on forage production of *D. annulatum*. Ahuja *et al.*, (1976) worked on the effect of different intensities of grazing stress on forage production in rangeland with *Lasiurus-Aristida* at Rajasthan and reported that the forage yield was significantly affected by grazing treatments, amount and distribution of rainfall. In 1978 he further noticed that the different grazing intensities had not affected the production of forage yield nor production of perennial grasses (*C. setigerus*) over a period of three years. The rainfall distribution had a very favorable influence on production of high perennial. The growth of heifers was highest when the animals were given concentrates from December to June and the growth rate was double under light intensity of grazing

Heitschmidt *et al.*, (1987) assessed the 14 Vs 42 paddocks rotational grazing on forage production and found that the above ground net primary production in the 2- RG-14 paddocks was lower as compared to single RG-42 paddocks. Undersomider *et.al.*, (1987) studied the grazing or clipping frequencies (1 week, 2 week and 4 weeks) effect on forage production on the wheat grass (*Andropyron elongatum*) and found that rotational grazing increased productivity. Sueijcar *et al.*, (1987) studied the influences of grazing pressure on rooting dynamics of Caucasian blue stem (*Bothriocloa caucasia*) in heavily and lightly grazed swards and observed that the total root length for heavily grazed sward was lower than length of lightly grazed sward. Eckert *et.al.*, (1987) also reported that basal growth decreased under heavily grazing as compared to protected area.

Pandya and Sidha (1989) evaluated the seasonal variation in plant biomass in grazing lands of Kutch District with grazed, ungrazed and light grazing treatments. This study showed that vegetation had seasonal variation with maximum yield in monsoon, which decreased in winter and dried up in summer. Similarly, Pandit *et. al.*, (1990) assessed the seasonal variations of plant biomass in semi-arid grassland at Bhavnagar and found maximum yield during rainy season and minimum in winter season. Joshi *et.al.*, (1991) studied the biomass and net primary productivity under a deferred grazing pattern

in a Himalayan grassland. They noticed that species diversity increased in deferred grazing compared with grazed and protected plots.

Singh and Shah (1991) compared the improved grassland and natural grazing area with introduction of grass-legume mixture (*Dactylis glomerata*, *Lolium perence*, *Trifolium pratence*) and found that the introduction of grasses and legumes resulted in highest per hectare returns compared to natural grazing area. Katewa and Tyagi (1991) assessed the productivity potential of grazing lands of Udaipur district on three major communities namely *Sehima*, *Heteropogon* and *Apluda* and observed that total net above ground annual primary production was maximum in *Heteropogon* and minimum in the *Apluda* community.

Mertia (1991) studied pasture and animal productivity from grazing lands dominated with *Cenchrus-Aristida* grass cover under rotational grazing system in semi-arid region and revealed that differences in forage yields between different grazing plots were not significant. However, rainfall and its distribution affected forage yields. Kanodia *et.al.*, (1993) studied the effect of fertilizer application on biomass production in *Sehima nervosum* at IGFRI, Jhansi on red gravelly, sandy clay soil and found that nitrogen significantly influenced the basal cover, number of tillers and dry forage yield. Misra *et. al.*, (1994) assessed the effect of clipping on the biomass of a coastal grassland in Orissa natural grassland predominated by *H.contortus*, *Bothriocloa odorta* and *Aristida setacea* and observed that the optimum height of clipping for maximum production was 15 cms. Seth (1996) conducted the study on biomass fluctuation in alpine pasture of Kashmir Himalayas under grazed and protected sites and found that biomass fluctuation had no definite trend at both grazed and protected sites but root: shoot ratio was higher at grazed site.

Trivedi (1997) studied management strategies of *Sehima-Heteropogon* grassland for forage yield under management practices viz., grazing and cutting with or without (N and P) at Jhansi in semiarid region. The results revealed that in cutting treatments the grasses responded to nitrogen and legume to phosphorus. Meenakshisundervalli and Paliwal (1997) studied the total net dry matter production in semi-arid region grassland. Of the total input about 75 percent was channeled to above ground and 25 percent to below ground. The nitrogen released to soil through root decay was higher than nitrogen

released through litter disappearance. Paine *et.al.*, (1997) evaluated pasture growth, production and quality under rotational and continuous grazing management at USA and found that relationship between forage mass and crude protein was higher in rotational grazing system than continuous. They concluded that ready to graze paddocks of rotational had significantly higher production than continuous grazing.

Herbage Quality: -

Jefferies and Rice (1969) studied the nutritive value of clipped and grazed range forage on short grass range with a rotation and a season long system. They compared the digestibility and protein values of clipped grass to fistula samples and found that the dry matter digestibility and protein levels were higher in fistula samples than in clipped samples. Chakravarty *et.al.*, (1970) evaluated the seasonal variation of crude protein in different pasture in semiarid region of India under different four pasture paddocks, three of which were sown pasture with different mixture of *C. ciliaris*, *C. setigerus*, *L. indicus* and fourth was natural protected grassland. Crude protein of perennial grasses varied in different seasons and it gradually decreased from September onward.

Shankarnarayan *et. al.*, (1977) determined the effect of manuring on the quality of *S. nervosum*, *C. ciliaris* and *C. setigerus*. They reported that the nitrogen application enhanced the crude protein in all the three grasses as well as dry matter yield in *Cenchrus* species but *S. nervosum* had not showed significant response to any level of nitrogen application. Kalmbacher *et. al.*, (1980) recorded the effect of plant height and cutting height on quality of *Indigofera hirsuta* and found that the plant height at initial harvest of stubble had the greatest influences on the percentage of crude protein.

Kanodia and Rai (1981) studied changes in chemical composition of range grasses in semi-arid region of India. The *Cenchrus*, *Sehima* and *Chrysopogon* and their varieties having less moisture requirement gave maximum quality forage yield during September while the highest quality dry matter yield was obtained during October in case of *Dichanthium* and *Bothriocloa* varieties with higher moisture regime. Rai *et. al.*, (1981) assessed the effect of Neem cake blended urea and its time of application on quality and quantity of *Sehima-Heteropogon* grassland at Jhansi and noted that *Sehima-Heteropogon* community with increasing levels of nitrogen during first two years gave higher

production while there was not definite trend during third year. Upadhyaya and Ramchandra (1990) evaluated the chemical composition and nutrient availability of some browse species of Bundelkhand region for goat and sheep production. Among eight natural shrubs *Zizyphus oenoplea* was found having maximum crude protein and minimum level of antiquality factor. All the shrubs were rich source of calcium but poor in phosphorus, copper and zinc.

Trivedi (1990) studied the effect of an approach for increasing herbage quality of range species with use of controlled burning with or without grazing in a *Sehima-Heteropogon* dominated grassland with no burning, annual, biennial, triennial burning treatments. The results revealed that the quality of *H. contortus* had increasing trend in successive years and calcium decreased to a considerable amount. Triennial burning coupled with grazing proved a good management practice for quality herbage from grassland. Rai and Upadhyay (1993) compared two tropical grass species for feeding value on growing sheep at IGFRI, Jhansi. Results showed that growing sheep could not maintain their growth on two natural grasses (*S.nervosum* and *C. ciliaris*) alone throughout the year. For sustained growth rate supplemental feeding of *Trifolium alexandrinum* hay was essential from November and onwards. Further they also noticed that *Cenchrus* pasture was found better than *S. nervosum* for sheep production. A study carried by Sood and Sharma (1994) in Kangra valley of H.P. for estimation of the effect of introduction of velvet bean in natural grassland with three-row spacing and three nitrogen levels revealed that velvet bean proved advantageous from quality and production point of view and fertilization affected the quality of herbage. However herbage quality was not affected by row spacing.

Gupta (1997) estimated the grazing impact on reducing sugar and starch contents of grassland vegetation in Shimla, and observed that the concentration percent of reducing sugar in above ground biomass was higher in rainy season while starch percent was higher in winter season. Singh *et.al.*, (1997) studied the effect of legume *Clitoria ternatea* on crude protein yield of different pasture grasses in silvipastoral system of production. The maximum crude protein percent was recorded in the *Clitoria* + *Cenchrus* combination, however *Clitoria* + *Cenchrus* + *Subabul* treatment proved to be most beneficial combination for crude protein yield.

IV. Animal Study

Herriat *et. al.*, (1959) studied the grazing animals and sward productivity through animal excreta and observed that the sheep grazing had an impact on increasing the yield of the grass/ clover directly attributable to effect of animal excreta. A fraction of the plant nutrients returned in the excreta of the grazing animals could be used by plants because of the chemical forms of the element in excreta. Vagel and Dyne (1966) reported the vegetation responses to grazing management (grazed and protected areas) and observed that total cover of herbaceous vegetation did not change to moderate grazing. The cover of grasses and sedges decreased slightly on grazed and protected areas, however some forbs decreased in cover of grazed areas.

Rauzi and Hanson (1966) assessed the water intake and run-off as affected by intensity of grazing and found that in heavily grazed watersheds recorded the highest run-off and lower water intake while lowest runoff and higher water intake were recorded in lightly grazed plots. Anderson (1967) evaluated the effect of rotation of deferred grazing in term of livestock production and reported that the grazing system as method of managing the range resource. Smoliak (1968) reported the grazing studies on native ranges, crested wheat grass and Russian wild rye pasture under continuously grazed, rotation and free choice systems of grazing. On rotation and free choice system production was found maximum on native grasses and the ewes rotated first to crested wheat grass then to native range and lastly Russian wild rye.

Piper (1968) compared the vegetation grazed and ungrazed pine for Juniper grassland sites in south central Mexico during 12 years. Gramas plants were higher on protected areas for all sites than grazed areas. The species composition was not significantly different between grazed and protected areas. Goodloc (1969) studied the short duration grazing in Rhodesia with varying periods of rest. There were significant indications that the short duration high intensity-grazing period is just as important range improvement as the rest period. Prajapati (1970) studied the effect of different systems of grazing by cattle on *Lasiurus-Eleusine-Aristida* grassland in arid region vis a vis animal production. Four months (August-November) grazing in early grazing was beneficial as

compared to continuous and deferred grazing. Although, the animal production was higher under continuous grazing.

Shankarnarayan (1977) assessed the impact of over grazing on grassland. The results revealed that over grazing changed botanical composition, palatability and yield of herbage. It triggers off succession and reduction in percent cover of desirable species. Dynamics of herbage productivity is influenced by the severity of grazing. Das and Paroda (1980) studied the rational utilization of grazing for sustained primary and secondary productivity in arid zone in terms the patterns of utilization (continuous & deferred rotational system) by sheep. Three years study revealed that patterns of utilization significantly influenced not only the trend and condition of the pasture plant community but also enhanced the animal production per unit of land when deferred rotational system was adopted. Dry matter was found maximum in deferred rotational while minimum in case of continuous grazing system. Similarly, Harsh and Yadav (1987) evaluated the effect of deferred rotational and continuous grazing of *Sporobolus-Eleusine* grassland at CAZRI, Jodhpur for six years and found that deferred rotational grazing was most suitable and also had positive effect on the maintenance of forage production but in continuous grazing the grass production declined over the time.

Sharma and Ogra (1990) studied influences of continuous grazing by goats and sheep under three tier pasture comprising *C. ciliaris* as ground cover, *Dichrostachys cinerea* as second tier and *Leucaena leucocephala* as top tier. Lambs consumed the grass cover of *C. ciliaris* but goat did not utilized. No mortality in *D. cinerea* was recorded and its leaves were quite palatable to both goat and sheep. Rai and Upadhyaya (1990) evaluated the performance of growing Mandya sheep on natural *Sehima-Heteropogon* grassland at IGFRI, Jhansi. The results indicated that Mandya sheep could perform satisfactorily on *Sehima-Heteropogon* dominant grassland from July to December. Mertia (1991) reported pasture and animal productivity from grazing land under rotational grazing system in semi-arid region of India. The rangeland was dominated by *Cenchrus-Aristida* grass cover. He noticed that maximum biomass was found during August while minimum during May-June.

Negi. *et al.*, (1993) observed high growth response of certain alpine meadows plants to clipping and grazing by horse and sheep. The height at which plants were grazed

was positively related to plant height. The correlation was significant only in case of horse and was higher in the horse grazed plants than in sheep grazed plants. This difference was due to deeper grazing by sheep than by horse. For forbs regrowth was better in grazed plants than in clipped plants. Rai and Verma (1995) evaluated the *D. annulatum* pasture with and without legume (*Stylosanthes hamata*) for sheep production in semiarid region of India. They concluded that mixed pasture (grass + legume) maintained the sheep for longer duration as well as getting the nutritious forage yield. Joshi (1995) studied the effect of grazing activity of cattle and goats in response to change in herb biomass of the grazing lands. The length of daily foraging track was longer for goat than for cattle. Seasonal patterns showed that the length of foraging track was significantly greater during winter and summer season than that during rainy season.

CHAPTER - 3

MATERIALS AND METHODS

Experimental site

The present study was carried out at the Central Research Farm of Indian Grassland and Fodder Research Institute, Jhansi ($25^{\circ} 31' N$ latitude and $78^{\circ} 32' E$ longitude and about 226 MSL) located in the Bundelkhand region. The region comprises some part of Uttar pradesh ($24^{\circ} 11' - 26^{\circ} 27' N$ latitude and $78^{\circ} 34' E$ longitude) and Madhya pradesh ($24^{\circ} 40' - 26^{\circ} 50' N$ latitude and $76^{\circ} 80' - 80^{\circ} 50' E$ longitude). According to Tyagi (1997) the total geographical area of the region is 71618 square Kilometer. The human population is over 12 million and the livestock population is 9.43 million, which include 5.36 million cattle, 1.64 million buffaloes, 1.83 million goats, 0.42 million sheep and 0.2 million other animals. Its intermixed undulating areas of varied slope characterize the topography of the region. The distribution of rainfall is often erratic, in August and July of the total about 70 percent rainfall occurred and about 90 percent of the total precipitation occurs between mid June to end of September. The rainfall varies between 750 mm in northwest to about 1200 mm in southwest. May and June are the hottest months with maximum temperature of $43-46^{\circ} C$ and the January is the coldest month and recorded minimum temperature $3-4^{\circ} C$.



Plate-I Study site with the lay out of the experiment

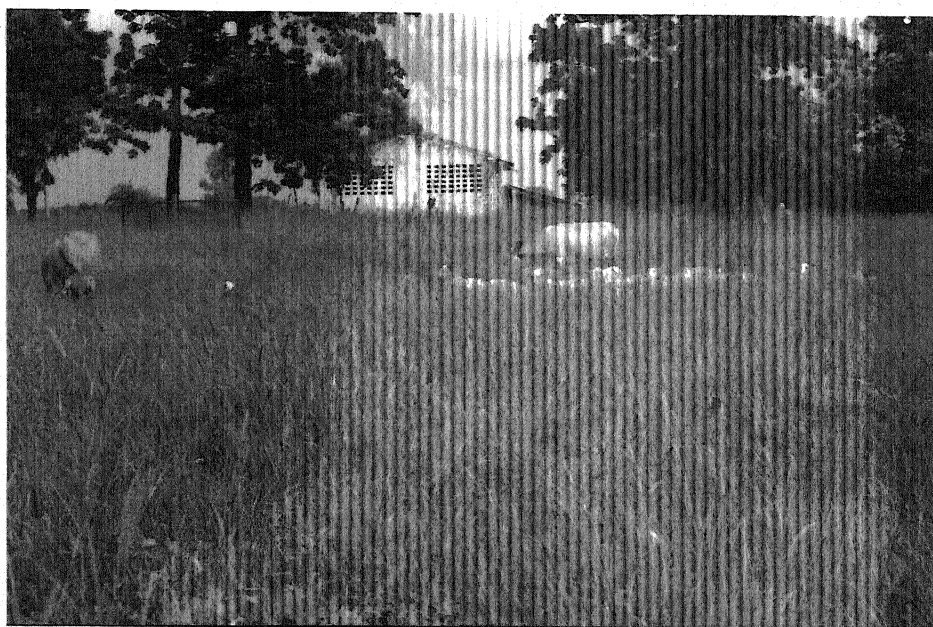
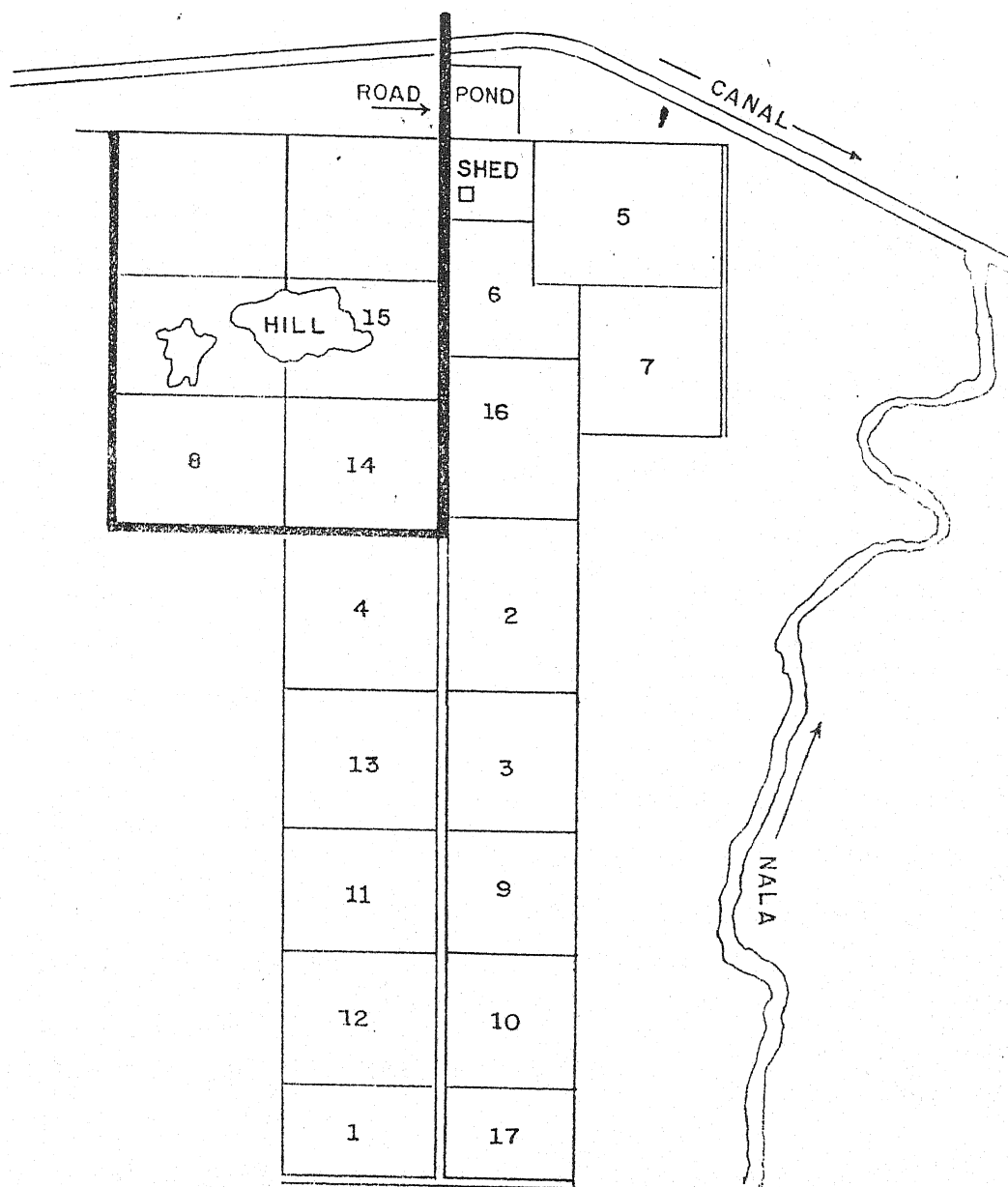


Plate-II Mixed herd grazing in rotational grazing system plot

NET - WORK PROGRAMME ON CROP BASED LIVESTOCK PRODUCTION SYSTEM



Grazing Systems

Plot No.

Rotational	4, 6, 11 & 15
Deferred rotational	3, 5, 9 & 13
Continuous	2, 7, 10 & 16
cut & carry	1, 8, 12 & 14
Standard control	17

The Bundelkhand area is termed as semi-arid region. The region has two major soil groups. Red soils are coarse and are found generally in Jhansi and Lalitpur Districts of U.P. where as Jalaun, Hamirpur, Mahoba, Sahujimaharajnagar and Banda district of U.P. have heavy black soils. These red and black soils are further classified into Rakar, Parwa, Kabar and Mar groups. Generally, poor nitrogen, medium phosphorus and high potash contents are found in red type of soil. In this area the rivers like Betwa, Ghagghar, Ken, Chandrawal and Pahuj provide water for irrigation. In this region about 50 percent of geographical area is covered by forests, none agriculture use land, barren and uncultivated land, cultivated wasteland, other fallow lands. About 43.2 percent area of this region is net sown area and about 29.8 percent of the net sown area is under irrigation. According by Ghosh (1991) the forest area of this region is about 16 percent of total geographical area. The vegetation of this region is tropical dry deciduous. Some selected areas in the forest are used for grazing by animals. The fallow lands, which are uncultivated due to various reasons, are used for growing grasses during rainy season and harvested mature grasses are conserved as hay or silage. After harvesting, these areas are opened for stubble grazing for limited period.

The period of this study was from June 1998 to May 2000. Present studies were under taken to analyze the vegetation dynamics of a grassland ecosystem under four grazing systems viz., rotational, deferred rotational, continuous grazing and cut & carry systems. Each system was replicated four times in RBD. The plot size is 1 ha each.

Microsite-1: - Plot no 4,6,11&15 for rotational grazing

Microsite-2:- Plot no.3, 5,9 &13 for deferred rotational grazing

Microsite-3: - Plot no.2, 7,10 &16 for continuous grazing

Microsite-4: - Plot no 1,8,12 &14 for Cut & Carry system

Climate

The study area falls under semiarid region. The climate is monsoon type and is characterized by dry summer, hot rainy season, warm autumn and cool winter. The average rainfall for study period was about 945 mm and 90 percent of the total rainfall occurred between July to September. June was the hottest month with mean maximum temperature 39.1°C and January was the coldest month with mean minimum temperature

of 5.1°C. Table No.1 Shown some meteorological parameters during study period. It is evident that Relative Humidity almost followed the patterns of rainfall and temperature. May shared lowest relative humidity followed by June. The wind velocity was maximum during June followed by May and July. Brightness or sunshine was most during May followed by April and February. The sunshine was least during December. The rate of evaporation was higher than rainfall during month of January and February and drought ness due to higher evaporation need compared to rainfall receipt during these months. Maximum evaporation was recorded during May followed by June.

Soil Study

The soil of the area is variable and major part is covered with red gravelly type of soil (alfi sols) with good porosity and drainage and some places had black loamy patches, semi rocky substratum, hillock areas. The texture, pH and available nutrients of study site are varied. The soil was almost neutral and soil nutrient status was of low to medium range.

Plant Study

Pasture Improvement

Grasses

1. *Cenchrus ciliaris* Linn. (Anjan ghas)

This genus belongs to the tribe panicae in which the two flowered spikelets fall ripe leaving no glumes. The spikelets are solitary and pedicels are never swollen. It is commonly known as buffel or Anjan grass and is very palatable at maturity. It makes reasonable quality hay when cut in early flowering stage.

2. *Cenchrus setigerus* Vahl. (Dhaman ghas)

It is selection from exotic material and adapted well to arid and semiarid regions of India. It is a drought hardy, early maturing, high tillering, quick generation ability, capable of giving 2-3 cuts in a year. Its averaged yield is 40 q/ha green fodder and 15 q/ha dry matter under arid condition. It is a leafy and highly nutritious for all kinds of livestock. In India it is called as Dhaman grass. Its drought resistance, hardiness, palatable and help in erosion control. The grass once established, with stands grazing

well and cutting 30 days intervals gave highest yield in Rajasthan and cutting frequencies at height (5,10 or 15 Cm) make no difference in this grass species.

3. *Chrysopogon fulvus* (Spreng) Chiv. (Dholu ghas)

It has densely tufted culms with long linear acuminate leaves. It is commonly known as Dholu grass. The grass is a valuable fodder and is cut just before flowering. It may also be used as a sand binder.

4. *Dichanthium annulatum* (Forsk) (Kel ghas)

It is commonly known as Kel ghas. It is palatable and used as hay in India. It has slender erect culms, nodes usually bearded, two or four racemes erect and rather close, pedunculate, first glume of the spikelet not indurates. Stalks of racemes hairy, pedicellate, spikelet usually male or bisexual, some time's neuter but with both glumes well developed and often with lemmas (Skerman and Riveros, 1992). It is widely adaptable, tolerant to alkaline soils and is effective in erosion control.

5. *Heteropogon contortus* (L) (Lampa ghas)

It is perennial, the culm erect to 75 cm, branching above leaf sheaths keeled, glabrous. Raceme solitary, 3.5-1.5 cm long up to 10 pairs of awnless spikelets at base and equal number of pairs above. Fertile sessile spikelets have 5-10 cm long awns. The grass is palatable in early stage but unattractive, as it's mature. Beside fodder its main attributes are hardness, perennially, tolerance to fire and ability to grow on poor soils.

6. *Sehima nervosum* (Willd) Stapf (Rats tail)

It is one of the most palatable grasses of the area and disappears quickly under grazing and used in haymaking. The species has densely tufted culms with leaf blades upto 30 cm. Racemes are solitary, 7-12 cm long, sessile spikelets pale green with long bristles from the upper glume and an awn about 45 mm long from the lemma, pedicel spikelet purplish.

Legumes

1. *Atylosia scarabaeoides* (Linn.) Benth (Chuha ghas)

It is a potential perennial pasture legume and is a climber forming thick mats, rootstocks. It is deep rooted and nodulated but nodules are few. Leaflets are elliptic, the lateral slightly oblique, 0.8-7.3 cm long. 0.5-3.0 cm wide rounded to subacute at both

ends. Inflorescence axillary, few flowered and peduncles 1.0-3.0 mm long. The protein contents ranged from 8.6 to 12.9 percent through out the year and averaged 1.6 percent calcium and 0.15 phosphorus levels. It occurs with *S. nervosum* but not with *H. contortus*.

2. *Clitoria ternatea* (Linn.) (Aparajita)

It is known as butter fly pea and native of tropical America, widely grown as an ornamental in the warmer part of the world. It is a climber, shrubby at base, 5-7 leaflets, and 3-5 cm long. Flowers are solitary, deep blue, occasionally pure white, very short pedicellate. Pods are flat, linear and beaked about 10 cm long. It is very palatable and its lack of persistence is often due to selective grazing by the animals. It is a drought resistance also asset. The percentage of crude protein ranged 13.5-19.5 percent.

3. *Macroptilium atropurpureum* (DC) Urb. (Siratro)

It is commonly known as *Siratro* and occurs naturally in central and South America. It has deep rooted with trailing pubescent stems. Leaves are pinnately trifoliate, dark green and slightly hairy on the upper. The inflorescence is a raceme, 6-12 flowers crowded at the apex. *Siratro* is palatable and livestock eat the runner's back toward the crown, which should be protected, from over grazing. *Siratro* hay can be made only with difficulty because of the heavy lost by leaf drop. It is able to competes with weed and many grasses (Skerman *et. al.*, 1992).

4. *Stylosanthes hamata* (Linn.) (Carribean Stylo.)

S. hamata is an exotic important pasture legume for dry tropical environments. It has been used widely in pasture improvement programs in northern Australia. It is poorly adapted to regions with <760 mm annual rainfall and to cooler environment with >300 m altitude. Some of differences between *S. hamata* and *S. scabra* are potentially important for cattle productivity particular differences in digestibility and sodium (Na) concentration. It is also known as caribbean *stylo* and a herbaceous annual to short lived perennial, much branched, semi erect with a dichotomously branching. Leaves are trifoliate with long, narrow, shiny leaflets. It is more palatable and makes excellent hay so long as it is cut before leaf fall commences.

5. *S. scabra* (Linn.) (Shrubby Stylo.)

It is commonly called as shrubby *stylo*, talled upto 2 meter, perennial legume, erect to sub erect. The stem is woody usually densely hairy, making them dry condition

and colour of stem vary from pale green to dark blue green. Leaves are trifoliate, leaflets hairy on both surfaces. This species is very drought tolerant, root very deeply penetrating taproot. Once established *S. scabra* is very strong competitor able to persist with *C. ciliaris*. It is not used in hay or silage making due to hardness of stem or branches.

Animal Component Study

In the improved pasture land four grazing systems viz., rotational, deferred rotational, continuous and cut & carry will be imposed. Each grazing system, there will be 9 sheep, 9 goats and 3 cows for this study; therefore the total number of 36 sheep, 36 goats and 12 cows will be taken. All the animals will be maintained throughout the year only on grazing from July to October and from November onward a concentrate of mixture will be offered @ 0.75 % of the body weight in addition to grazing.

Methods

Climatic Study

The microclimate parameter viz., air temperature, relative humidity (RH) and rainfall were measured at fortnightly intervals on clear sky days. Air temperature was recorded through infrared thermometer while relative humidity (RH) was measured by using a dial type self-indicating hair hygrometer.

Soil Study

The soil samples were taken from two different depth viz., depth (0-15 cm) and (15-30 cm). The samples were taken by post-hole auger. Before taking samples vegetation was cleared from the land surface. For analysis, soil samples were air dried in shade; crushed with a wooden pestle and mortar and passed through a 2 mm (10 mesh) and leveled samples were packed in polythen bags.

The soil pH was estimated by using digital glass electrode pH meter at a ratio of 1:2 soil water suspension and soil moisture was determined by drying a known weight in a hot air oven at 105°C till constant weight. The soil texture was observed by Bauyoucos hydrometer method as prescribed by Piper (1966).

The available nutrients (NPK) were measured by different methods of soil analysis. Available nitrogen was determined adopting alkaline permagnate method (Piper 1966) and Olsen et al., (1954) method, determined available phosphorus. The available potassium was estimated by flame photometer. The estimation of organic carbon was done by Walkey and Black's method.

Plant Study

Pasture Improvement Method

The area was fenced and divided into the paddocks (1.0 ha each) for grazing purpose and over number of nonpalatable and undesirable bushes were removed. Contour bunding was done for sloppy land with less than 6 % slope. The reseeding of suitable potential forage species (grasses and legumes) had done according to habitat and climatic condition. Grasses were *Cenchrus ciliaris*, *C. setigerus*, *Chrysopogon fulvus*, *Dichanthium annulatum* etc., while legumes were *Atylosia scarabaeoides*, *Clitoria ternatea*, *Macroptileum atropurpureum*, *Stylosanthes hamata* and *S. scabra*. All paddocks were improved through the seed mixture of grasses and legumes pasture. A single basal dose of fertilizer at @ 20 kg N/ha and 20 kg P₂O₅/ha was given to all 16 paddocks at sowing time and 20 kg N/ha was applied at top dress at 1.5-2.0 months sowing or establishment.

Herbaceous Component

Before introduction of grazing animals, botanical composition was studied through the line interception method and for this 20 transects (2 meter) were taken from each paddock and computing percentage relative composition, basal cover, frequency and Importance Value Index (IVI) were computed for all the constituent species. The vigour of 10 plants of prominent grasses and legumes were studied at the 50 % flowering from each plot. The productivity from herbaceous vegetation was determined in term of plant biomass. For plant biomass "Harvest method" was employed, for this Quadrat was used. Ten Quadrats (50x50 cm) were harvested from each paddock and this harvested material was sorted out into different species and species groups viz., perennial grasses, annual grasses, other grasses, legumes, forbs and litter.

Woody Component

The total numbers of individual of woody species were counted for percentage composition/ density. Growth data were recorded in the month of May-June of year. The growth of woody vegetation was analyzed through different growth parameters viz., collar diameter and number of branches per plant. The collar diameter (cd) was measured at the base with the help of tree caliper. The numbers of branches were estimated as branch raised from main stem. For this study 10 percent of the total number of woody plants per hectare were studied of each species. The productivity of woody/shrub component was measured in term of fuel wood and top feed production in each paddock of each grazing system. Of which three plants of each species were selected (one large, one medium and one small size) and felled during the months of April-May in each year. After felling, the whole plant was kept under shade in cleaned area or tarpaulin. For top feed, leaves were separated and weighed. The main stem and other branches were kept under for sundry for about one month from the date of felling and weighed for determination of fuel wood production. The average value of three plants of each species was calculated to represent the fuel wood and top feed production.

Forage Quality

The chemical composition of pasture herbage was estimated for growth and post growth period. Forage samples were collected from each plot of each grazing system and was analyzed for chemical characters viz., dry matter (DM), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL). Before analysis, samples were thoroughly washed successively and make moisture free by pressing the plants between filter papers. The plant samples then dried in a hot air oven maintained at 80°C and grinded. Finally grinded samples were estimated for crude protein as Kjeldahl method prescribed by A.O.A.C. (1988) and forage fibre contents (NDF, ADF, and ADL) were determined by method of Goering H.K. and Van soest P.J. (1970).

Animal Study

The grazing was started after establishment of pasture properly in the all paddocks and allowed @ 1.5 ACU (Adult Cow Unit) per hectare in a ratio of 1:1 of sheep & goats and cow. Thus in each grazing system all the animals were maintained through out the year. From July to November the animals were maintained only on grazing, there after from December to June they were offered with concentrate mixture @ 0.75 kg of body weight in addition to grazing. The body weight changes were recorded at fortnightly intervals in seasonally during growth and post growth period of vegetation.

Grazing methods

The following grazing systems were employed during study period. Each grazing system was grazed by 9 sheep+ 9 goat+ 3 cow.

1. Rotational

In this grazing system all the animals will be kept together and 7 days rotation will be followed in the four plots (4,6,11 &15).

2. Deferred rotational

In this system, out of four plots (3,5,9 &13) one plot was left ungrazed till maturity of pasture to allow seed formation and three plots were grazed following 7 days rotation but after seed dispersion deferred plot was also grazed following 7 days rotation.

3. Continuous

All the animals were allowed to graze simultaneously in four plots (2,7,10 &16) of 1.0 hectare each.

4. Cut & Carry

In this system the animals will be maintained primarily on the stall fed condition and forage will be harvested from their four plots (1,8,12 &14) and offered.

CHAPTER - 4

RESULTS

I. Climate

Rainfall (total precipitation), temperature, humidity and solar radiation (light) are the main environmental factors. These are discussed in detail for study and are furnished in Table-1 and Figure-1.

Rainfall

The rainfall is chief environmental factor to plant growth because plants need water for their physiological processes. In the 1998 year, the total rainfall of 905.6 mm was recorded in 45 rainy days. Highest rainfall (423.2 mm) was recorded in the month of July, where as during 1999 the total rainfall of 1118.2 mm was recorded in 52 rainy days and highest rainfall (478.6 mm) was received in the month of September. No rainfall was received during winter season in the both years.

Temperature

All the chemical processes of metabolism of a plant and also many physical processes are dependent upon temperature. The amount of heat received depends upon the angles of sun's rays and their consequent absorption. The actual temperatures at the

Table-1. Meteorological data at C R Farm IGRI, Jhansi during study period

Month	Temperature (°C)				RH % (period)				Rain fall (mm)		Rainy days		Wind velocity (km/h)		Bright Sunshine (h/day)	
	1998		1999		1998		1999		1998	1999	1998	1999	1998	1999	1998	1999
	Max.	Min.	Max.	Min.	I	II	I	II								
Jan.	21.7	5.9	21.7	5.7	96	46	95	51	0.0	8.2	0	1	1.1	1.2	7.9	7.7
Feb.	26.0	9.2	27.3	10.3	91	33	90	27	1.8	0.0	0	0	2.1	1.3	8.9	9.2
Mar.	26.9	13.0	35.2	12.4	90	32	74	25	22.8	0.0	3	0	3.6	2.8	9.5	10.5
Apr.	38.5	25.3	42.0	20.0	72	24	45	19	5.4	0.0	1	0	3.1	4.2	10.0	10.2
May	42.9	26.4	41.4	25.3	56	22	60	26	17.0	22.4	2	1	6.7	6.9	10.4	10.1
June	39.8	28.1	39.2	27.2	63	38	67	40	73.3	19.4	6	2	7.8	7.5	6.9	7.7
July	33.7	25.8	35.0	26.6	86	68	83	60	423.2	250.2	14	13	5.1	6.7	4.8	4.2
Aug.	32.5	25.3	31.7	24.4	92	72	91	74	281.9	323.8	13	17	1.8	2.6	3.7	4.7
Sep	33.8	24.9	31.2	24.1	91	60	95	72	80.2	478.6	6	16	2.1	0.7	8.5	4.6
Oct.	33.4	19.6	31.9	17.9	88	51	91	46	0.0	15.6	0	2	1.7	0.4	8.3	8.6
Nov.	29.1	12.8	29.6	10.4	87	38	88	32	0.0	0.0	0	0	1.3	0.5	8.1	8.9
Dec.	25.8	6.2	24.3	6.5	91	56	94	38	0.0	0.0	0	0	0.7	0.5	2.2	7.2

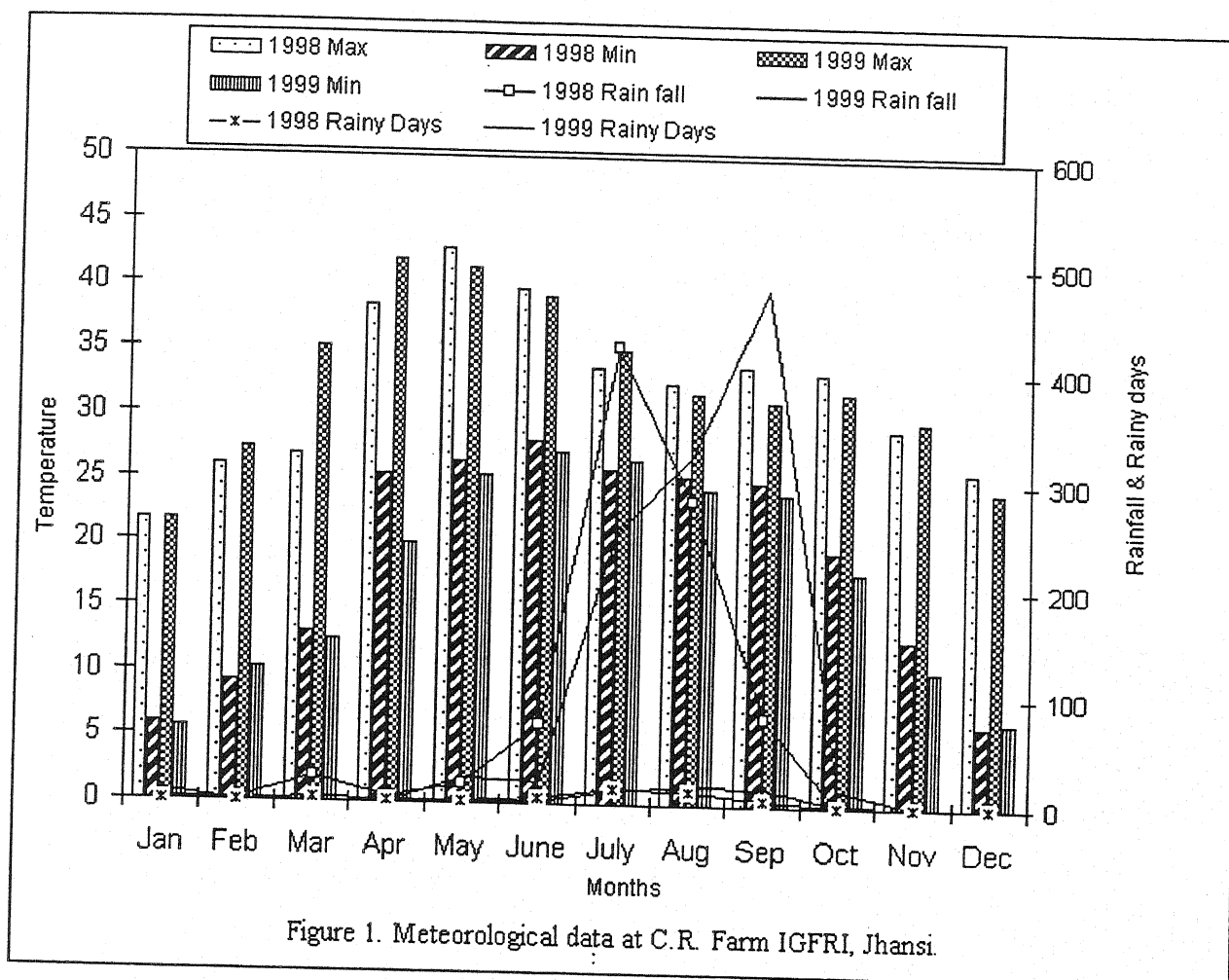


Figure 1. Meteorological data at C.R. Farm IGFRI, Jhansi.

surface of the earth are greatly modified by radiation, conduction and convection (Pearson, 1930). The mean maximum temperature of 42.9°C in the month of May and minimum temperature of 5.9°C were recorded in the month of January during the 1998 year, while during 1999 the mean maximum temperature of 42.0°C in the month of April and mean minimum temperature 5.7°C were recorded in the month of January.

Relative Humidity

Humidity is also most important factor because it directly affects the rate of transpiration and relative humidity (RH) is the ratio, expressed at percentage of water vapour present in the air at a temperature to the amount of necessary to saturate the same unit of space under similar condition. During 1998 year the RH was found to be highest (96%) in the month of January and minimum 22 percent in the month of May, while in the year 1999 the maximum Relative Humidity was 95 percent in the month of January and September; however, the minimum RH (19%) was received in the month of April.

The average highest value of evaporation (11.0 and 10.8 mm/day) were recorded in the both year respectively and a lowest value of evaporation (1.8 mm/day) was recorded in the month of January for both years. The data recorded on the wind velocity during 1998 year the average maximum wind velocity (7.8 km/hr) in the month of June and minimum (0.7 km/hr) was received during month of December, while in 1999 year the peak value of wind velocity was also recorded in June of year and minimum (0.4 km/hr) was observed in the month of October.

Solar Radiation

Light or solar radiation is one of the major controlling factor of microclimate because green plants get sun's energy in the process of photosynthesis. The availability of solar radiation has important implication for productivity of grasses and other vegetation. The data recorded during the year 1998 the average brightest sunshine (10.4 hr/day) hours in day was found in the month of May and lowest average sunshine (2.2 hr/day) was observed in the month of December. Where as in the year 1999 the maximum average bright sunshine (10.5 hr/day) was noticed during month of March and minimum (4.2 hr/day) was recorded in the month of July.

II. Soil Study

The soil is the important edaphic factor of any terrestrial ecosystem. The availability of nutrients like nitrogen, phosphorus, and potassium in the soil is also important in most of such ecosystem (Bruilnzal, 1991). Each of these elements has unique pattern of sources, transformation and availability to plants under varying environmental conditions (Mengel and Kirkby, 1982).

Physical Characters

Soil Texture

The soil of the site has 53.1% sand, 32.3 % clay and 15.2% silt. There are not much difference in soil texture in different grazing systems and the soil is sandy clay type.

pH

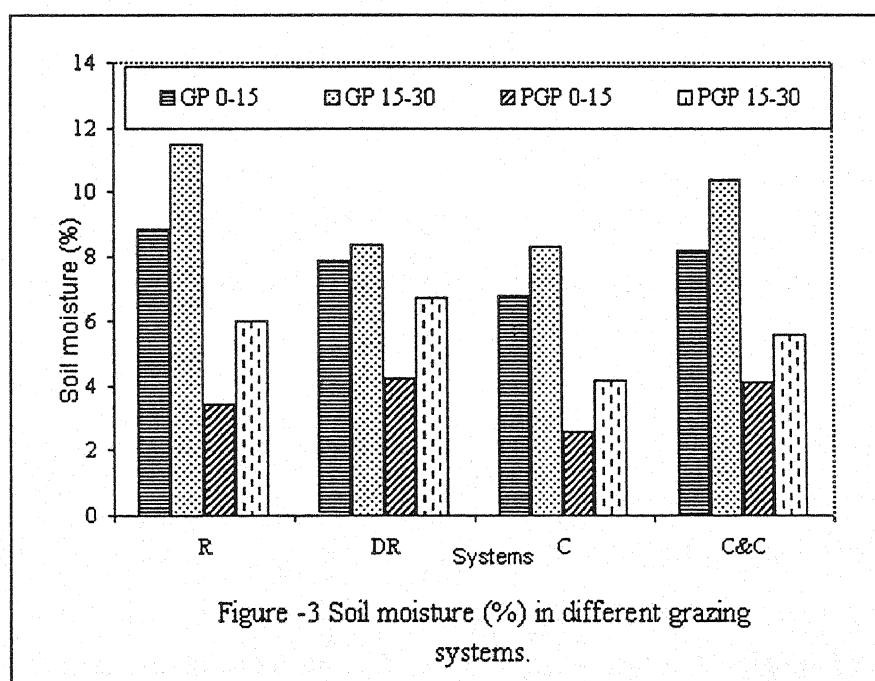
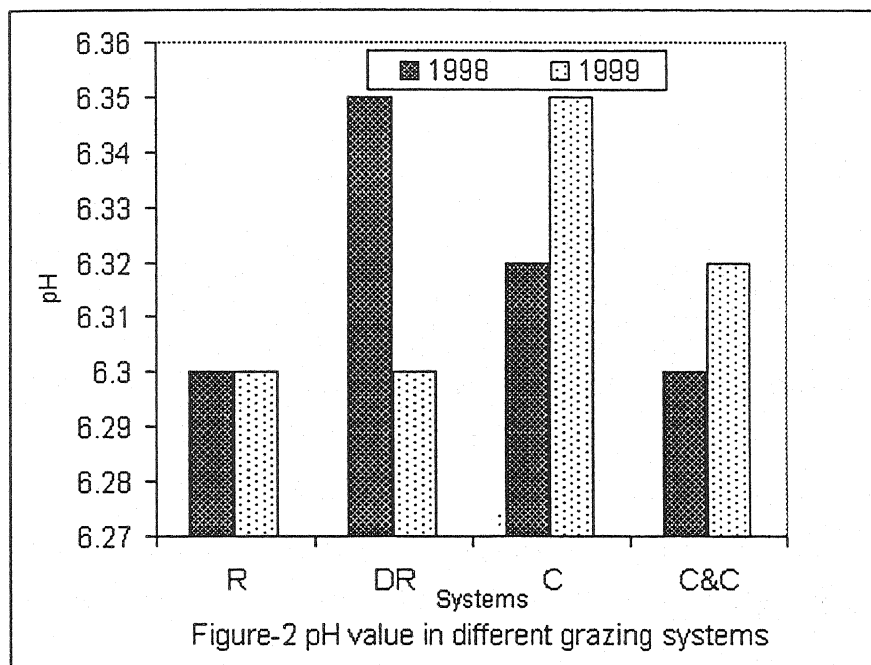
The results (Table-2 and Figure-2) revealed that the mean soil pH ranged from 6.30 to 6.35 under different systems of utilization during both years. During first year, maximum pH (6.35) was recorded in deferred rotational and minimum (6.30) in rotational and Cut & carry system while in second year of study, higher pH (6.35) noticed in continuous and lower (6.30) in rotational and deferred rotational systems.

Soil moisture

The plants take up the soil nutrients in the form of solution therefore the soil moisture is very important. The soil moisture availability in different seasons at the two depths 0-15 cm and 15-30 cm for the all four microsites is presented in Table-3 and Figure-3. The data recorded on soil moisture revealed that peak value of soil moisture content 8.86 percent at the depth 0-15 cm was found in rotational system and least moisture 6.78 percent was in continuous system during growth period of vegetation, while at the depth (15-30 cm) it ranged from 8.31 to 11.48 percent in continuous and rotational system respectively. During the post growth period the moisture content was found in decreasing trend as compared to growth period at the both depths. The maximum moisture 4.19 and 6.74 percent was noticed in deferred rotational and

Table- 2. Physical and chemical characteristics of soil in different systems.

Systems	pH		Organic carbon (%)		Available nutrients (kg/ha)					
					N		P		K	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Rotational	6.30	6.30	0.50	0.54	185.7	200.7	6.8	7.5	165.5	170.0
Deferred rotational	6.35	6.30	0.55	0.58	205.0	217.0	7.2	8.1	172.0	185.5
Continuous	6.32	6.35	0.50	0.52	187.2	190.0	6.6	7.5	160.8	165.5
Cut & Carry	6.30	6.32	0.52	0.50	190.5	180.5	6.8	7.9	165.5	158.0



minimum 2.59 and 4.15 percent was in continuous system at the both depths (0-15 & 15-30 cm) during post growth period.

Chemical characters

Organic Carbon

The organic carbon content in the soil varied from 0.50 to 0.58 percent in both years. These variations among different systems, however, cannot be ascribed to the management systems at this stage because of the heterogeneity among the paddocks. During 1998 year, maximum organic carbon percent (0.58) was found in deferred rotational while minimum (0.50) was in continuous system. In deferred rotational grazing system the organic carbon content was higher (0.58%) followed by rotational system (0.54%), continuous (0.52%) and cut & carry system (0.50%) in the 1999 year (Figure-4).

Nitrogen

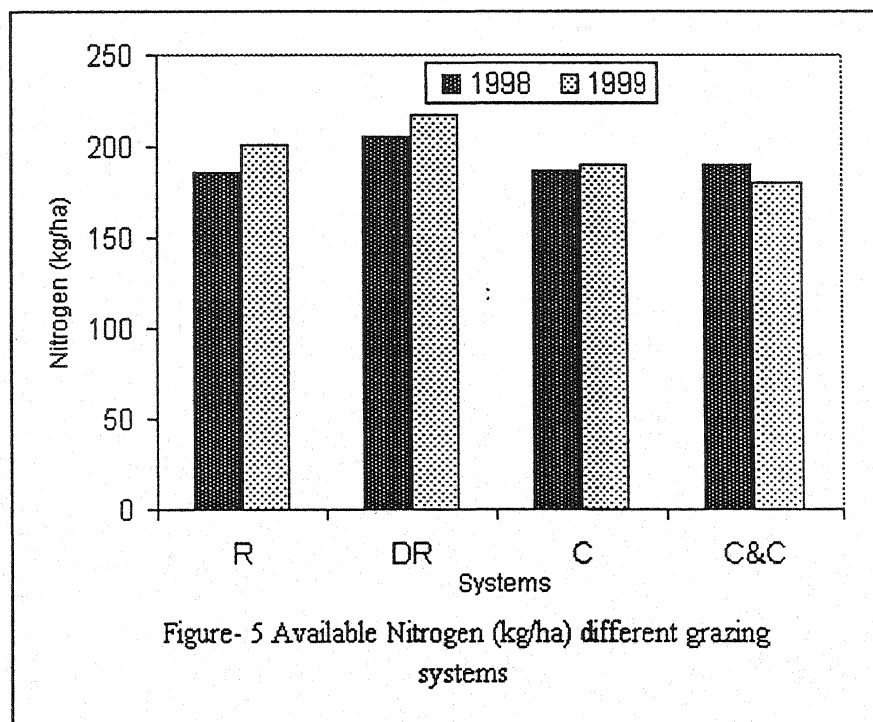
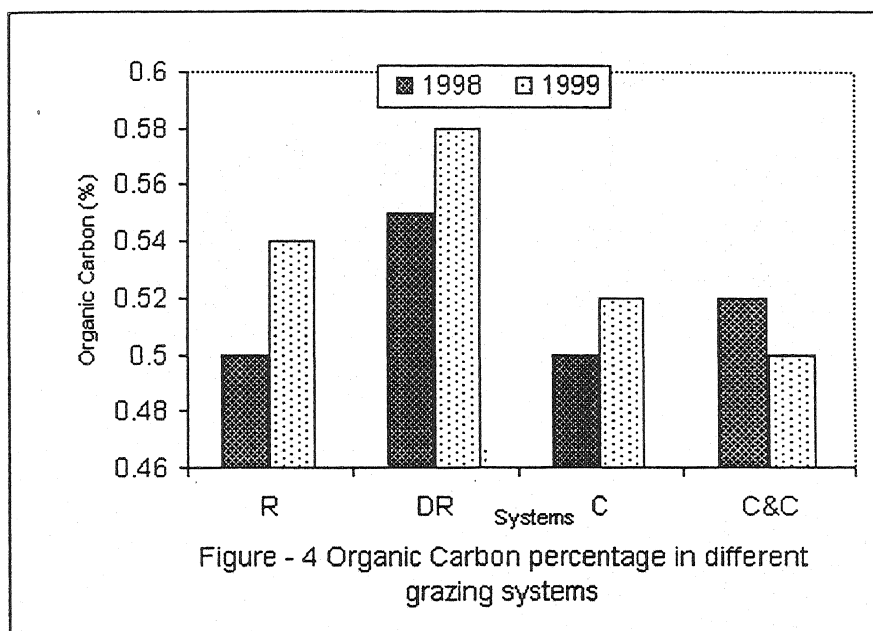
The available nutrients nitrogen, phosphorus and potassium were significant related among different microsites for the both years and have been presented in Table-2 and Figure-5. The data revealed from the first year of study that the available nitrogen contents ranged from 185.7 to 205.0 kg/ha in rotational and deferred rotational system, respectively, while during second year of the study the status of available nitrogen ranged from 180.5 to 217.0 kg/ha in cut & carry and deferred rotational system.

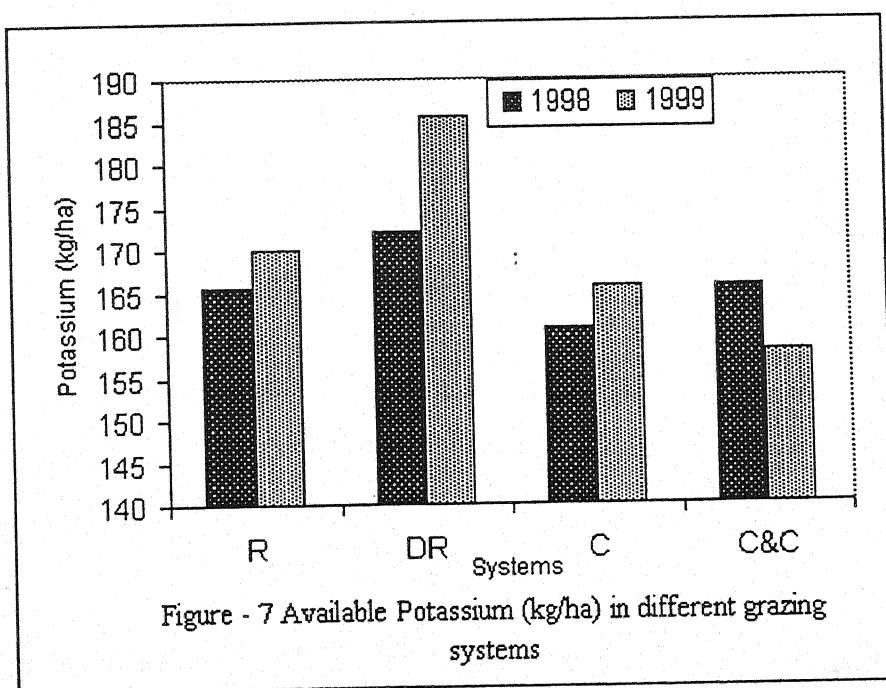
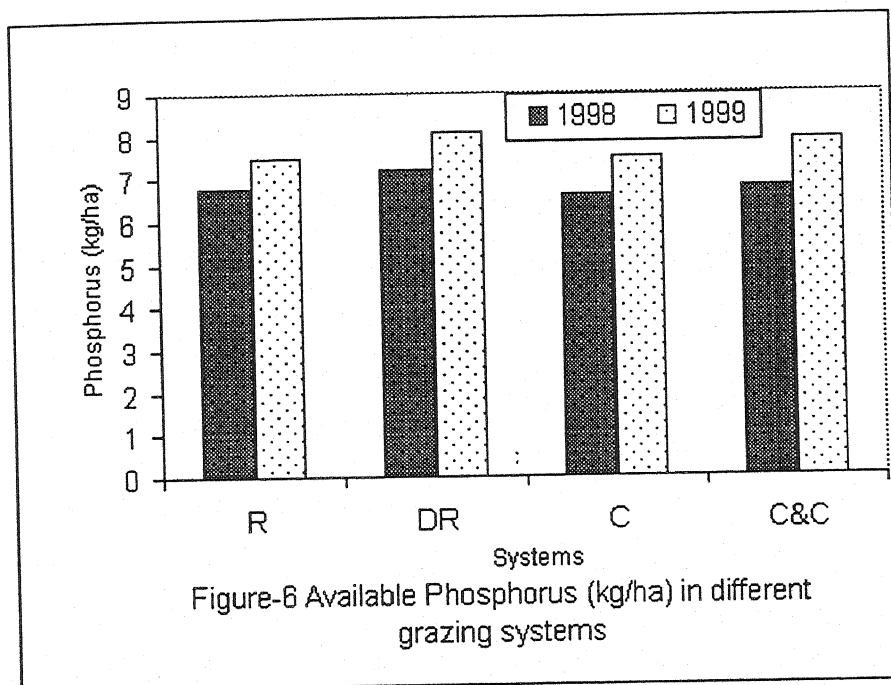
Phosphorus

The available phosphorus in the study area, soil did not differ much among different systems for the both years (Figure-6). However, the highest value (7.2 kg/ha) was recorded in deferred rotational and lowest (6.6 kg/ha) was recorded in the continuous system in the first year. The data indicated from table that the quantity of phosphorus content was increased in the second year of study and it was ranged 7.5 to 8.1 kg/ha in continuous and deferred rotational system, respectively.

Table- 3. Soil moisture (%) for growth and post growth period in different systems.

Systems ↓ Depths →	Growth period		Post growth period	
	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)
Rotational	8.86	11.48	3.40	5.97
Deferred rotational	7.87	8.37	4.19	6.74
Continuous	6.78	8.31	2.59	4.15
Cut & Carry	8.22	10.41	4.08	5.56





Potassium

The available potassium ranged from 160.8 to 172.0 kg/ha under continuous and deferred rotational system for the 1998 year while the status of potash during 1999 it was from 158.0 to 185.5 kg/ha in cut & carry and deferred rotational system (Figure-7). The results from both years, observations indicate that the four utilization systems did not show marked variations in the soil fertility parameters, however, deferred rotational was found relatively superior to others systems due to recorded relatively higher values of organic carbon and other available nutrients.

III. Plant study

A. Studies on herbaceous vegetation

Structure

Vegetation composition is most essential for understanding the community structure. According to Braun-Blanquet (1932), the sociological study deals with the description and classification of plant community. The species composition is one of the major anatomical character of community. To understand the importance of the vegetation, Curtis and McIntosh (1950) employed the concept of Importance Value Index (IVI). It is a pooled value of three analytic characters such as relative dominance, relative composition and relative frequency. It gives better information about the dominance and ecological success of any species.

Species Diversity

Total 33 herbaceous species were listed from the sites during the study period and there were 12 grasses (6 perennial and 6 annual), 9 legumes and 12 forbs (Table-5). The prominent species were as below-

Grasses

1. *Cenchrus ciliaris*
2. *Dichanthium annulatum*
3. *Heteropogon contortus*
4. *Setaria nervosum*

5. *Brachiaria ramosa*
6. *Eragrostis pilosa*
7. *Setaria glauca*

Legumes

1. *Atylosia scarabaeoides*
2. *Indigofera astragalina*
3. *Phaseolus trilobatus*
4. *Stylosanthes hamata*

Forbs

1. *Borreria stricta*
2. *Corchorus fascicularis*
3. *Euphorbia hirta*
4. *Evolvulus alsinoides*
5. *Triumfetta rhomboidea*

The species diversity recorded in different grazing systems is depicted/ furnished in Table-4 and Figure-8. It is obvious from the table that in first year of study (1998) the total number of species were maximum (24) in deferred rotational and minimum (19) in continuous grazing system. In second year (1999) maximum number of species (26) were found in rotational and cut & carry system, while minimum (24) was in deferred rotational system. It is noted that except deferred rotational the number of species increased in rest three systems in second year. It is also found that among grasses the number of annual grasses remained constant and number of perennial grasses decreased in rotational and cut & carry system in consecutive year. Contrary to grasses, legumes and forbs got increased in almost all the systems during second year (Figure-8).

Table- 4. Species diversity in different systems.

Species group	Rotational		Deferred rotational		Continuous		Cut & Carry	
	1998	1999	1998	1999	1998	1999	1998	1999
Perennial grasses	5	3	5	5	4	4	5	4
Annual grasses	6	7	6	6	6	6	6	6
Legumes	5	8	5	6	4	7	5	7
Forbs	5	8	8	7	5	8	5	9
Total	21	26	24	24	19	25	21	26

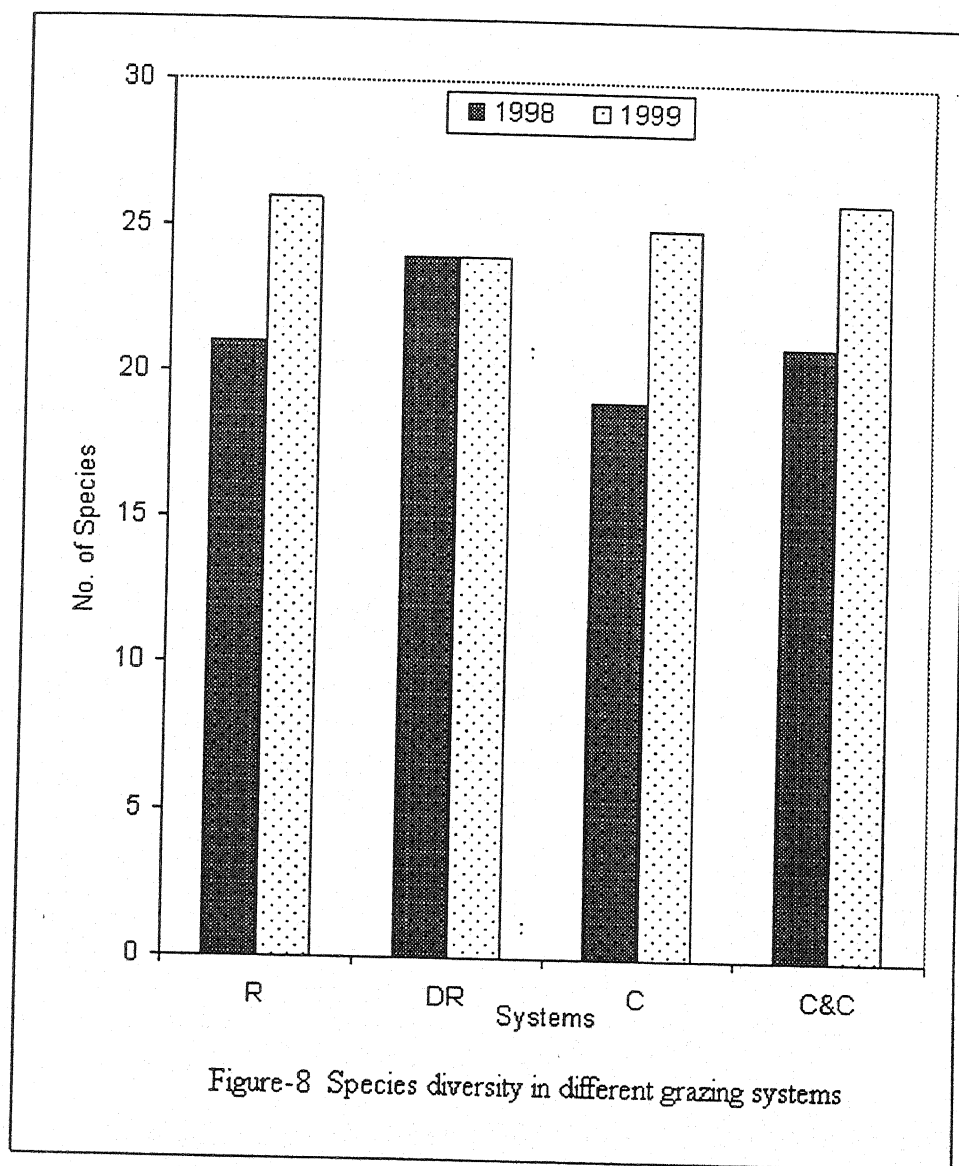


Table- 5. List of species found in different grazing systems

Species	Rotational		Deferred rotational		Continuous		Cut & Carry	
Grasses	1998	1999	1998	1999	1998	1999	1998	1999
Perennial grasses								
<i>C. ciliaris</i>	+	+	+	+	+	+	+	+
<i>C. fulvus</i>	-	-	-	-	-	-	+	-
<i>D. annulatum</i>	+	+	+	+	+	+	+	+
<i>H. contortus</i>	+	+	+	+	+	+	+	+
<i>I. laxum</i>	-	-	-	+	-	+	-	-
<i>S. nervosum</i>	+	+	+	+	+	+	+	+
Annual grasses								
<i>A. varia</i>	+	+	-	-	-	+	-	-
<i>B. ramosa</i>	+	+	+	+	+	+	+	+
<i>D. adscendens</i>	+	+	+	+	+	+	-	+
<i>E. pilosa</i>	+	+	+	+	+	+	+	+
<i>S. glauca</i>	+	+	+	+	+	+	+	+
<i>T. quadrivalvis</i>	-	-	-	-	-	-	-	+
Legumes								
<i>A. scarabaeoides</i>	+	+	+	+	+	+	+	+
<i>A. longifolius</i>	-	+	+	+	-	-	-	+
<i>C. pumila</i>	-	+	+	+	+	+	+	+
<i>C. ternatea</i>	-	+	-	+	-	+	+	+
<i>D. biflorus</i>	-	+	-	+	-	+	+	+
<i>I. astragalina</i>	+	+	+	+	+	+	+	+
<i>Matropurpureum</i>	-	-	-	-	+	+	-	+
<i>P. trilobatus</i>	+	+	+	+	+	+	+	+
<i>S. hamata</i>	+	+	+	+	-	+	-	+
Forbs								
<i>B. stricta</i>	+	+	+	+	+	+	+	+
<i>C. viscosa</i>	-	-	+	+	+	+	-	+
<i>C. fascicularis</i>	+	+	+	+	+	+	+	+
<i>C. argentea</i>	+	+	-	+	+	+	+	+
<i>E. hirta</i>	+	+	+	+	+	+	+	+
<i>E. alsinoides</i>	+	+	+	+	+	+	-	+
<i>I. mauritiana</i>	-	+	+	+	-	+	-	+
<i>L. aspera</i>	+	+	+	+	-	+	+	+
<i>P. virgatus</i>	-	-	-	-	-	+	-	-
<i>S. cordifolia</i>	+	-	-	-	-	-	-	-
<i>T. rhomboidea</i>	+	+	+	+	+	+	+	+
<i>T. procumbens</i>	+	-	+	+	-	+	-	-

+ Present, - Absent

Botanical Composition

The present chapter deals with the variations in vegetation composition at four microsites viz., rotational, deferred rotational, continuous and cut & carry in both the years. During the year 1998, *S. nervosum* was dominant in three systems namely deferred rotational, continuous and cut & carry systems while *H. contortus* was co-dominant. Where as in rotational system *C. ciliaris* was dominant grass with *H. contortus* as co-dominant. Among these grasses the IVI (Importance Value Index) of the *C. ciliaris* was higher (73.6) in the rotational system while that of the *S. nervosum*, *H. contortus* and *D. annulatum* were maximum 65.8, 54.5 and 40.0 IVI in the cut & carry, rotational and continuous systems, respectively (Table-9). The data recorded in the year 1999, *H. contortus* was a dominant grass in all the four systems while *S. nervosum* was co-dominant in three systems namely rotational, continuous and cut & carry with 47.6, 38.3 and 38.4 IVI.

Among legumes *I. astragalina* achieved maximum (30.9) and (18.4) IVI in cut & carry in the both years. The higher IVI of legume species in cut & carry was due to there was no grazing and legume survived with out any disturbance (Table-9).

Triumfetta rhomboidea a natural forb species was recorded highest IVI (25.4) in cut & carry system followed by (23.3) in deferred rotational, (21.6) in rotational in the 1998 year while higher value (17.1) IVI of *T. rhomboidea* was found in the deferred rotational system during the 1999 year of study.

Growth

The growth of herbaceous vegetation was computed in term of plant vigour. The role of plant vigour is very important attribute of grassland in forage production. The vigour attributes viz., plant height, tusk area, leaf length, number of leaves, total tillers, number of effective tillers, spike length and number of seeds per spike for all prominent grasses and for legumes vigour characters like plant height, stem diameter, leaf length, leaf width, number of leaves, pod length, number of pods and number of seeds per pod were studied in all the four grazing systems during both years and furnished in Table-10, 11, 12 & 13.

Botanical Composition

The present chapter deals with the variations in vegetation composition at four microsites viz., rotational, deferred rotational, continuous and cut & carry in both the years. During the year 1998, *S. nervosum* was dominant in three systems namely deferred rotational, continuous and cut & carry systems while *H. contortus* was co-dominant. Where as in rotational system *C. ciliaris* was dominant grass with *H. contortus* as co-dominant. Among these grasses the IVI (Importance Value Index) of the *C. ciliaris* was higher (73.6) in the rotational system while that of the *S. nervosum*, *H. contortus* and *D. annulatum* were maximum 65.8, 54.5 and 40.0 IVI in the cut & carry, rotational and continuous systems, respectively (Table-9). The data recorded in the year 1999, *H. contortus* was a dominant grass in all the four systems while *S. nervosum* was co-dominant in three systems namely rotational, continuous and cut & carry with 47.6, 38.3 and 38.4 IVI.

Among legumes *I. astragalina* achieved maximum (30.9) and (18.4) IVI in cut & carry in the both years. The higher IVI of legume species in cut & carry was due to there was no grazing and legume survived with out any disturbance (Table-9).

Triumfetta rhomboidea a natural forb species was recorded highest IVI (25.4) in cut & carry system followed by (23.3) in deferred rotational, (21.6) in rotational in the 1998 year while higher value (17.1) IVI of *T. rhomboidea* was found in the deferred rotational system during the 1999 year of study.

Growth

The growth of herbaceous vegetation was computed in term of plant vigour. The role of plant vigour is very important attribute of grassland in forage production. The vigour attributes viz., plant height, tusk area, leaf length, number of leaves, total tillers, number of effective tillers, spike length and number of seeds per spike for all prominent grasses and for legumes vigour characters like plant height, stem diameter, leaf length, leaf width, number of leaves, pod length, number of pods and number of seeds per pod were studied in all the four grazing systems during both years and furnished in Table-10, 11, 12 & 13.



Plate-III Data recording of botanical composition of grassland through line interception method

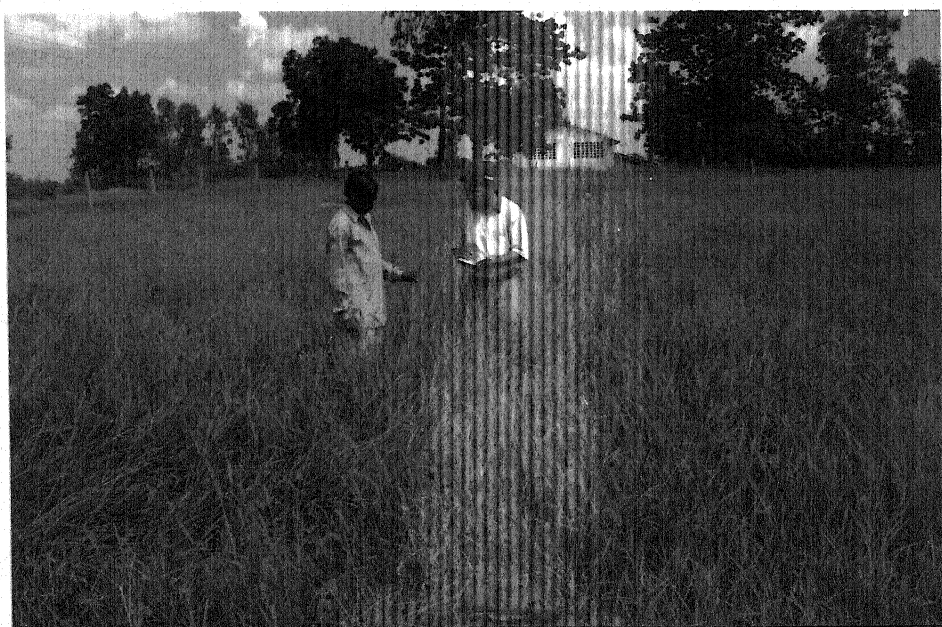


Plate-IV Measuring of vigour attributes of range grasses in grassland

Table-6. Relative dominance of different species under four grazing systems.

Species	Rotational		Deferred rotational		Continuous		Cut & Carry	
	1998	1999	1998	1999	1998	1999	1998	1999
Grasses								
<i>C. ciliaris</i>	61.6	22.9	22.2	28.2	5.3	0.3	24.7	15.0
<i>C. fulvus</i>	-	-	-	-	-	-	1.5	-
<i>D. annulatum</i>	2.2	0.06	9.7	4.4	25.6	13.8	1.0	1.0
<i>H. contortus</i>	29.4	29.3	21.6	35.7	25.1	35.1	24.5	35.4
<i>I. laxum</i>	-	-	-	1.6	-	18.8	-	-
<i>S. nervosum</i>	24.5	29.4	39.2	19.2	31.5	22.6	42.4	25.4
<i>A. varia</i>	0.02	0.2	-	-	-	0.02	-	-
<i>B. ramosa</i>	0.7	4.5	0.6	1.1	4.0	1.4	0.3	8.3
<i>D. adscendens</i>	0.9	0.6	0.03	1.2	1.8	1.0	-	2.3
<i>E. pilosa</i>	3.9	5.5	2.7	0.9	3.8	0.7	2.3	1.6
<i>S. glauca</i>	0.03	1.4	0.2	2.0	0.04	3.4	0.04	2.6
<i>T. quadrivalvis</i>	-	-	-	-	-	-	-	0.5
Legumes								
<i>A. scarabaeoides</i>	0.06	1.4	0.1	0.02	0.3	0.1	0.5	0.1
<i>A. longifolius</i>	-	-	0.04	0.3	-	-	-	0.1
<i>C. pumila</i>	-	0.3	0.1	0.1	0.2	0.04	0.3	0.4
<i>C. ternatea</i>	-	0.2	-	0.1	-	0.02	-	0.04
<i>D. biflorus</i>	-	0.05	-	0.1	-	0.1	-	0.3
<i>I. astragalina</i>	0.8	0.5	0.7	0.7	0.7	0.3	0.9	1.2
<i>M. atropurpureum</i>	-	-	-	-	-	-	-	-
<i>P. trilobatus</i>	0.8	0.1	0.3	0.1	0.5	0.1	0.2	0.3
<i>S. hamata</i>	0.2	0.5	0.6	0.5	-	0.7	-	1.5
Forbs								
<i>B. stricta</i>	0.06	0.6	0.04	0.4	0.2	0.2	0.1	0.6
<i>C. viscosa</i>	-	-	0.5	0.02	0.4	0.2	-	0.1
<i>C. fascicularis</i>	0.1	0.5	0.04	0.6	0.4	0.3	0.3	0.5
<i>C. argentea</i>	0.06	0.5	-	0.4	0.04	0.02	0.1	1.2
<i>E. hirta</i>	0.4	0.2	0.3	0.5	0.1	0.1	0.1	0.5
<i>E. alsinoides</i>	0.3	0.2	0.2	0.2	0.04	0.1	-	0.04
<i>I. mauritiana</i>	-	0.1	-	0.3	-	0.02	-	0.2
<i>L. aspera</i>	0.02	0.3	0.04	0.4	-	0.1	0.02	0.4
<i>S. cordifolia</i>	0.03	-	-	-	-	-	-	-
<i>T. rhomboidea</i>	2.1	0.5	0.6	0.8	0.2	0.3	0.5	0.1
<i>T. procumbens</i>	3.6	-	0.1	-	-	-	-	-

Table-7. Relative composition of different species under four grazing systems.

Species	Rotational		Deferred rotational		Continuous		Cut & Carry	
	1998	1999	1998	1999	1998	1999	1998	1999
Grasses								
<i>C. ciliaris</i>	8.2	6.4	11.1	7.1	1.7	0.3	6.8	6.0
<i>C. fulvus</i>	-	-	-	-	-	-	0.4	-
<i>D. annulatum</i>	1.3	0.3	4.0	2.1	9.5	5.4	0.6	0.7
<i>H. contortus</i>	12.4	11.0	9.4	11.2	10.1	15.7	8.1	11.3
<i>I. laxum</i>	-	-	-	0.6	-	6.5	-	-
<i>S. nervosum</i>	7.4	9.7	8.1	6.6	7.1	8.5	11.2	6.9
<i>A. varia</i>	0.6	0.7	-	-	-	0.3	-	-
<i>B. ramosa</i>	9.3	9.7	10.4	1.5	15.1	2.6	6.8	12.0
<i>D. adscendens</i>	2.1	1.7	0.7	1.5	2.6	3.4	-	2.3
<i>E. pilosa</i>	4.0	7.4	3.7	1.2	3.9	2.6	3.1	2.0
<i>S. glauca</i>	0.6	1.4	4.1	3.7	1.0	10.3	1.3	2.7
<i>T. quadrivalvis</i>	-	-	-	-	-	-	-	0.7
Legumes								
<i>A. scarabaeoides</i>	1.7	1.7	2.5	0.2	5.8	1.8	7.6	1.2
<i>A. longifolius</i>	-	-	1.5	2.5	-	-	-	0.7
<i>C. pumila</i>	-	3.8	3.0	1.9	4.5	0.8	6.4	4.7
<i>C. ternatea</i>	-	1.7	-	1.2	-	1.5	-	0.3
<i>D. biflorus</i>	-	0.3	-	0.9	-	1.5	-	1.3
<i>I. astragalina</i>	15.2	5.3	14.5	7.2	12.9	5.4	16.1	8.3
<i>M. atropurpureum</i>	-	-	-	-	0.2	-	-	-
<i>P. trilobatus</i>	3.8	1.0	4.1	1.5	5.2	1.5	5.3	2.9
<i>S. hamata</i>	1.4	6.0	0.2	7.5	-	10.8	-	11.6
Forbs								
<i>B. stricta</i>	1.3	7.1	1.0	4.6	4.3	3.1	2.5	4.9
<i>C. viscosa</i>	-	-	0.2	0.2	0.2	2.3	-	0.3
<i>C. fascicularis</i>	4.4	6.4	1.0	6.5	7.7	6.1	6.9	3.6
<i>C. argentea</i>	1.4	1.4	-	4.4	0.9	0.3	3.0	4.7
<i>E. hirta</i>	5.2	3.1	4.1	6.5	3.0	2.3	2.3	5.3
<i>E. alsinoides</i>	1.7	2.8	2.5	2.5	0.4	1.8	-	0.3
<i>I. mauritiana</i>	-	1.7	0.2	3.7	-	0.3	-	1.6
<i>L. aspera</i>	0.6	3.6	1.5	4.0	-	1.5	0.4	3.3
<i>S. cordifolia</i>	0.2	-	-	-	-	-	-	-
<i>T. rhomboidea</i>	13.1	5.0	1.9	8.4	4.3	3.8	11.0	0.7
<i>T. procumbens</i>	3.8	-	0.2	-	-	-	-	-

Table-8. Relative frequency of different species under four grazing systems.

Species	Rotational		Deferred rotational		Continuous		Cut & Carry	
	1998	1999	1998	1999	1998	1999	1998	1999
Grasses								
<i>C. ciliaris</i>	3.8	3.0	5.8	3.1	0.6	0.7	4.0	2.8
<i>C. fulvus</i>	-	-	-	-	-	-	0.7	-
<i>D. annulatum</i>	1.6	0.6	5.1	2.1	4.9	3.3	1.6	0.5
<i>H. contortus</i>	12.7	10.6	8.5	8.7	8.8	13.3	8.9	8.9
<i>I. laxum</i>	-	-	-	0.5	-	3.3	-	-
<i>S. nervosum</i>	8.6	8.5	6.8	6.0	8.2	7.3	12.2	6.1
<i>A. varia</i>	0.6	1.5	-	-	-	0.7	-	-
<i>B. ramosa</i>	8.6	0.6	10.2	2.6	13.1	4.0	6.6	10.3
<i>D. adscendens</i>	2.2	3.0	0.7	2.6	2.3	4.0	-	3.3
<i>E. pilosa</i>	3.2	4.5	4.1	1.8	2.3	1.7	3.3	1.9
<i>S. glauca</i>	0.6	2.1	3.4	3.9	1.6	6.7	1.6	2.8
<i>T. quadrivalvis</i>	-	-	-	-	-	-	-	0.5
Legumes								
<i>A. scarabaeoides</i>	2.2	3.6	3.4	0.5	5.6	1.7	6.6	0.5
<i>A. longifolius</i>	-	-	1.7	1.8	-	-	-	1.4
<i>C. pumila</i>	-	5.1	4.1	2.6	6.5	1.7	5.0	6.1
<i>C. ternatea</i>	-	3.0	-	1.3	-	1.7	-	0.5
<i>D. biflorus</i>	-	0.6	-	1.8	-	3.3	-	1.9
<i>I. astragalina</i>	14.3	7.5	13.5	7.9	10.5	6.7	13.9	8.9
<i>M. atropurpureum</i>	-	-	-	-	0.6	-	-	-
<i>P. trilobatus</i>	6.4	2.1	5.8	2.6	7.2	1.7	5.6	4.2
<i>S. hamata</i>	5.4	4.5	0.7	5.3	-	9.0	-	8.3
Forbs								
<i>B. stricta</i>	2.2	5.1	1.7	5.3	5.6	4.0	2.3	4.7
<i>C. viscosa</i>	-	-	0.7	0.5	0.6	2.3	-	0.5
<i>C. fascicularis</i>	4.8	8.2	1.7	8.7	8.2	6.0	7.3	4.7
<i>C. argentea</i>	2.2	2.1	-	3.1	1.6	0.7	3.3	5.5
<i>E. hirta</i>	4.8	6.1	5.1	8.7	4.9	4.0	2.3	6.9
<i>E. alsinoides</i>	3.2	3.0	3.4	1.8	0.6	3.3	-	0.5
<i>I. mauritiana</i>	-	3.6	0.7	5.3	-	0.7	-	1.9
<i>L. aspera</i>	1.6	4.5	1.7	4.5	-	3.3	0.7	4.2
<i>S. cordifolia</i>	0.6	-	-	-	-	-	-	-
<i>T. rhomboidea</i>	6.4	5.1	10.8	7.9	4.9	4.0	13.9	1.4
<i>T. procumbens</i>	3.2	-	0.7	-	-	-	-	-

Table -9. IVI of different species under four grazing systems.

Species	Rotational		Deferred rotational		Continuous		Cut & Carry	
	1998	1999	1998	1999	1998	1999	1998	1999
Grasses								
<i>C. ciliaris</i>	73.6	32.3	39.9	38.4	7.6	1.3	35.5	23.8
<i>C. fulvus</i>	-	-	-	-	-	-	2.6	-
<i>D. annulatum</i>	5.1	0.9	18.8	8.6	40.0	22.5	3.2	2.2
<i>H. contortus</i>	54.5	50.9	39.5	55.6	44.0	64.1	41.5	55.6
<i>I. laxum</i>	-	-	-	2.7	-	28.6	-	-
<i>S. nervosum</i>	40.5	47.6	54.1	31.8	46.8	38.3	65.8	38.4
<i>A. varia</i>	1.2	2.4	-	-	-	1.0	-	-
<i>B. ramosa</i>	18.6	14.8	21.2	5.2	32.2	8.0	13.7	30.6
<i>D. adscendens</i>	5.2	5.3	1.4	5.3	6.7	8.4	--	7.9
<i>E. pilosa</i>	11.1	17.4	10.5	3.9	11.0	5.0	8.7	5.5
<i>S. glauca</i>	1.2	4.9	7.7	9.6	2.6	20.4	2.9	8.1
<i>T. quadrivalvis</i>	-	-	-	-	-	-	-	1.7
Legumes								
<i>A. scarabaeoides</i>	3.9	6.7	6.0	0.7	11.7	3.6	14.7	1.9
<i>A. longifolius</i>	-	-	3.2	4.6	-	-	-	2.2
<i>C. pumila</i>	-	9.2	7.2	4.6	11.2	2.5	11.7	11.2
<i>C. ternatea</i>	-	4.9	-	2.6	-	3.2	-	0.8
<i>D. biflorus</i>	-	0.9	-	2.8	-	4.9	-	3.5
<i>I. astragalina</i>	30.3	13.3	28.7	15.8	24.1	12.4	30.9	18.4
<i>M. atropurpureum</i>	-	-	-	-	0.8	-	-	-
<i>P. trilobatus</i>	10.3	3.2	10.2	4.2	12.9	3.3	11.1	7.4
<i>S. hamata</i>	7.0	11.0	1.5	13.3	-	20.5	-	21.4
Forbs								
<i>B. stricta</i>	3.6	12.8	2.7	10.3	10.1	7.3	4.9	10.2
<i>C. viscosa</i>	-	-	1.4	0.7	0.8	4.8		0.9
<i>C. fascicularis</i>	9.3	15.1	2.7	15.8	16.3	13.1	14.5	8.8
<i>C. argentea</i>	3.7	4.0	-	7.9	2.5	1.0	6.4	11.4
<i>E. hirta</i>	10.4	9.4	9.5	15.7	8.0	6.4	4.7	12.7
<i>E. alsinoides</i>	5.2	6.0	6.1	4.5	1.0	5.2	-	0.8
<i>I. mauritiana</i>	-	5.4	0.9	9.3	-	1.0	-	3.7
<i>L. aspera</i>	2.2	8.4	3.2	8.9	-	4.9	1.1	7.9
<i>S. cordifolia</i>	0.8	-	-	-	-	-	-	-
<i>T. rhomboidea</i>	21.6	10.6	23.3	17.1	9.4	8.1	25.4	2.2
<i>T. procumbens</i>	10.6	-	1.0	-	-	-	-	-

Vigour of prominent grasses

The data arranged in Table-10 & 11 reveal the vigour of some prominent grasses viz., *C. ciliaris*, *H. contortus*, *S. nervosum*, *D. annulatum* and *I. laxum* for both years. During the first year i.e. 1998, *C. ciliaris* attained higher values (135.4 cm) plant height, (41.28 cm) leaf length and (10.7 cm) spike length in the rotational system and in 1999 *C. ciliaris* also reached higher values of plant height (128.2 cm), Leaf length (47.9 cm), spike length (13.4 cm), number of leaves per tiller (23.2), number of seeds per spike (103.0) and tusk area (390.4 cm²) in the rotational system. In deferred rotational system the number of leaves (27.0) and number of seeds per spike (121.4) were maximum in the first year while number of tillers (85.4) and number of effective tillers (31.0) were maximum in the second year.

In case of *H. contortus*, the vigour characters like plant height (142.7 cm), number of leaves per tiller (37.8) and spike length (13.3 cm) were higher in rotational system, while lower value in vigour characters was observed in continuous system during the first year (Table-10). However, higher vigour characters were found in the cut & carry system in the second year of study (Table-11).

S. nervosum showed better growth in continuous system during the first year (Table-10), while it showed higher values of vigour in rotational system in the 1999 year (Table-11).

D. annulatum a perennial grass was recorded higher value of plant height (136.8 cm), number of leaves per tiller (26.4), spike length (11.4cm) and number of seeds per spike (33.0) in the rotational system during the first year (Table-10), while it showed higher vigour characters like plant height (116.9 cm), number of effective tillers (17.2) and spike length (6.9 cm) under the continuous system in the second year (Table-11).

I. laxum achieved maximum value of plant vigour in the cut& carry system while the minimum values of vigour were observed in the deferred rotational system during the both year (Table-10 & 11), however the maximum vigour characters viz., plant height (115.4 cm), number of tillers (178.6), number of effective tillers (133.0) and tussock area (258.2 cm²) were found in the rotational system in the second year of study (Table-11).

Table-10. Plant vigour of range grasses in different systems (1998)

Grazing System	Plant height (cm)	Average No. of leaves	Leaf length (cm)	Average Tusk area (cm ²)	Average No. of tillers	Average No. of Effective Tillers	Spike length (cm)	Average No. of seeds/spike
1. <i>Cenchrus ciliaris</i>								
Rotational	135.4	17.8	41.28	642.1	89.2	22.2	10.7	69.2
Deferred rotational	113.2	27.0	34.8	624.0	59.6	20.4	10.0	121.4
Continuous	91.8	26.0	24.7	591.0	89.8	16.0	5.9	50.8
Cut & Carry	80.5	23.2	31.9	78.6	91.6	23.4	8.9	97.2
2. <i>Heteropogon contortus</i>								
Rotational	142.7	37.8	26.5	254.8	137.4	62.6	13.3	31.2
Deferred rotational	120.3	30.4	20.5	450.6	260.0	179.0	12.5	28.2
Continuous	136.0	36.4	22.2	501.2	124.2	29.0	12.0	28.4
Cut & Carry	152.6	31.6	26.7	475.1	141.8	78.8	13.3	36.6
3. <i>Sehima nervosum</i>								
Rotational	150.8	9.0	42.2	414.9	124.8	43.4	13.8	46.8
Deferred rotational	160.3	7.8	36.9	359.9	150.0	68.2	14.1	35.2
Continuous	142.8	13.0	39.8	317.3	152.0	59.4	13.6	49.0
Cut & Carry	157.7	8.4	42.5	313.2	118.0	64.6	15.8	43.8
4. <i>Dichanthium annulatum</i>								
Rotational	136.8	26.4	30.5	31.5	92.6	11.6	11.4	33.0
Deferred rotational	104.7	17.6	22.7	37.4	68.6	16.0	7.2	31.6
Continuous	80.6	7.6	24.7	135.6	101.0	31.8	6.2	29.6
Cut & Carry	93.0	11.2	31.0	382.2	178.0	—	—	—
5. <i>Iseilema laxum</i>								
Rotational	86.9	48.8	13.5	45.7	132.8	89.0	2.9	3.0
Deferred rotational	80.6	25.0	14.8	307.9	45.0	25.0	2.1	2.0
Continuous	92.7	51.2	17.1	37.7	112.2	62.4	3.2	4.0
Cut & Carry	105.7	47.2	15.9	148.0	183.4	113.4	3.1	3.8

Table-11. Plant vigour of range grasses in different systems (1999)

Grazing Systems	Plant height (cm)	Average No. of leaves	Leaf length (cm)	Average tusk area (cm ²)	Average No. of tillers	Average No. of effective tillers	Spike length (cm)	Average No. of seeds/spike
1. <i>Cenchrus ciliaris</i>								
Rotational	128.2	23.2	47.9	390.4	52.8	19.2	13.4	103.0
Deferred rotational	114.7	22.4	42.4	341.6	85.4	31.0	9.1	85.4
Continuous	106.4	19.0	35.9	75.0	65.4	27.4	10.2	91.2
Cut & Carry	119.5	18.4	41.7	159.4	44.6	18.6	10.2	99.4
2. <i>Heteropogon contortus</i>								
Rotational	137.0	21.4	28.3	146.8	105.8	51.0	15.4	21.6
Deferred rotational	123.0	19.0	29.0	182.8	140.6	79.6	14.7	23.6
Continuous	153.8	26.6	28.0	269.3	109.6	79.8	13.1	24.6
Cut & Carry	153.9	22.6	32.2	342.9	125.8	97.6	14.1	25.6
3. <i>Setaria nervosa</i>								
Rotational	162.0	9.6	41.2	295.1	180.2	108.4	19.5	38.6
Deferred rotational	150.6	7.6	36.7	435.8	172.0	87.8	16.4	34.0
Continuous	143.3	8.0	23.9	412.6	125.2	80.4	13.8	34.6
Cut & Carry	169.7	9.2	41.2	371.7	164.2	112.8	16.8	43.4
4. <i>Dichanthium annulatum</i>								
Rotational	97.0	22.4	22.6	58.5	109.6	8.0	5.7	22.4
Deferred rotational	107.7	11.4	23.7	65.9	53.8	11.0	5.7	23.6
Continuous	116.9	16.0	23.2	47.6	42.2	17.2	6.9	30.0
Cut & Carry	108.2	22.0	17.9	49.2	94.8	8.6	6.5	30.8
5. <i>Isolema laxum</i>								
Rotational	115.4	44.2	19.7	258.2	178.6	133.0	—	—
Deferred rotational	95.1	38.0	19.1	221.7	112.0	50.6	—	—
Continuous	113.6	36.8	23.5	134.0	160.4	97.8	—	—
Cut & Carry	112.6	56.6	18.7	188.8	112.6	73.6	—	—

Vigour of range legumes

The vigour of three legumes namely *S. hamata*, *A. scarabaeoides* and *I. astragalina* was studied. The vigour characters include plant height, stem diameter, leaf length, leaf width, number of leaves, pod length, number of pods and number of seeds per pod of each species are presented in Table-12 &13.

S. hamata exhibited higher growth characters in terms of plant height (109.2 cm), leaf length (2.5 cm), leaf width (0.9 cm) and average number of branches/plant (36.6) in the continuous system in the first year while species showed higher values of characters like plant height (74.4.cm), number of leaves (288.0), leaf length (3.0 cm) and number of branches (11.2) in the cut & carry system in consecutive year (1999).

In the case of *A. scarabaeoides* the maximum plant height (120.7cm), number of leaves (335.2), number of pods (29.2), pod length (2.3 cm) and number of seeds per pod (5.4) was recorded in the first year of study in rotational and minimum in the deferred rotational while during the second year the higher value of vigour characters was found in the deferred rotational and lower in the rotational system.

The maximum value of *I. astragalina* growth was recorded in the rotational system and minimum was in continuous system in the both years of study. The higher values, numbers of leaves (460.2), number of pods (279.8), number of seeds per pod (6.2) and stem diameter (0.6 cm) were found in the rotational system.

Productivity

The herbaceous species constitutes the major source of fodder during July to December in semi arid region. The pasture species play a key role in any improvement and more intensive system of land utilization. According to Pandeya (1988) full use of pasture resources and conserving them to the region of negative feed back, alone will lead to plan maintenance of homeostatic plateau for lasting economy. In present study the forage production was recorded for two periods viz., growth (July-September) and post growth period (October-December) and is represented in the (Table-15a, 15b, 16a&16b).

Table-12. Plant vigour of range legumes in different systems (1998).

Grazing Systems	Plant Height (Cm)	Number Of leaves	Leaf Length (Cm)	Leaf Width (Cm)	Number Of pods	Pod Length (Cm)	Number Of seeds/ Pod	Number of Branches/ plant
1. <i>Atylosia scarabaeoides</i>								
Rotational	120.7	335.2	3.6	1.9	29.2	2.3	5.4	—
Deferred rotational	116.0	220.4	3.3	2.2	22.4	2.0	5.4	—
Continuous	106.2	126.0	3.9	2.4	1.8	1.7	4.4	—
Cut & Carry	106.1	258.4	3.5	2.1	20.0	2.0	5.4	—
2. <i>Indigofera astragalina</i>								
Rotational	72.4	152.2	4.0	1.6	78.4	1.6	4.8	—
Deferred rotational	67.4	202.4	4.0	1.8	85.2	1.5	5.4	—
Continuous	44.8	150.6	3.7	1.4	47.8	1.4	5.2	—
Cut & carry	57.9	241.0	3.2	2.3	61.8	1.3	5.4	—
3. <i>Stylosanthes hamata</i>								
Rotational	52.8	284.4	2.0	0.6	—	—	—	21.2
Deferred rotational	68.6	292.0	2.3	0.7	—	—	—	13.0
Continuous	109.2	393.4	2.5	0.9	—	—	—	36.6
Cut & carry	90.7	506.0	1.6	0.7	—	—	—	26.0

Table- 13. Plant vigour of range legumes in different systems (1999).

Grazing Systems	Plant Height (Cm)	Number Of leaves	Leaf Length (Cm)	Leaf Width (Cm)	Number Of pods	Pod Length (Cm)	Number Of seeds/ Pod	Number of Branches/ Plants
1. <i>Atylosia scarabaeoides</i>								
Rotational	88.2	136.2	4.0	2.1	9.4	2.3	4.4	—
Deferred rotational	134.4	331.0	4.4	2.5	61.2	2.5	5.4	—
Continuous	95.4	189.4	3.1	1.8	12.4	2.3	5.2	—
Cut & Carry	98.4	161.8	3.8	2.4	8.0	2.1	5.0	—
2. <i>Indigofera astragalina</i>								
Rotational	85.3	460.2	4.9	2.2	279.8	1.8	6.2	—
Deferred rotational	97.9	239.0	4.7	2.5	203.2	1.9	5.4	—
Continuous	72.2	362.2	5.4	2.0	233.2	1.6	5.4	—
Cut & Carry	83.9	334.0	4.7	2.2	245.4	1.7	5.4	—
3. <i>Stylosanthes hamata</i>								
Rotational	69.8	81.2	2.4	0.8	—	—	—	6.2
Deferred rotational	69.8	172.8	1.9	0.7	—	—	—	3.8
Continuous	51.8	73	2.4	0.7	—	—	—	4.0
Cut & carry	74.4	288.0	3.0	0.6	—	—	—	11.2

Biomass at growth period

Results on forage production of different species and species groups for growth period of different systems are described below and furnished in Table-14, and 15a .

In the first year the total dry forage production ranged from 6.37 to 7.94 t/ha in cut & carry and rotational systems respectively. The total contribution of grass component was about 92.1, 91.4, 91.7 and 83.7 percent of the total production in continuous, rotational, deferred rotational and cut & carry systems respectively (Fig-9). Among grasses the highest production (2.94 t/ha) was recorded by *H. contortus* in the rotational system. *S. nervosum* was next important contributor and produced 2.22 t/ha dry forage production in the continuous system. *H. contortus* was the most dominant species in the community and *S. nervosum* was the co-dominant grass species (Table-14).

Data of total dry forage production recorded during in the year 1999 at growth period are depicted in Table-15b and Figure-12. The total dry forage production ranged from 6.49 to 8.40 t/ha in cut & carry and rotational system respectively, which was approximately 2 to 6 percent higher over the previous year in these systems. About 11 to 15 percent decrease in forage production was recorded in deferred rotational and continuous systems in comparison to last year. The contribution from grasses was highest (7.22t/ha) in rotational while lowest (4.62 t/ha) was observed in the continuous system. *S. nervosum* a perennial grass recorded higher dry forage production (3.10 t/ha) in the rotational system when compared to different plant species production of different grazing systems (Table-14). The *H. contortus* was the next grass species and achieved higher dry forage production in the deferred rotational system followed by continuous, rotational and cut & carry systems respectively.

Legume component produced maximum forage (0.64 t/ha) in cut & carry and minimum (0.15 t/ha) in continuous system (Table-15a and Figure-10). The total contribution of leguminous species was 1.9, 4.1, 2.9 and 10.0 percent of the total dry forage production in continuous, rotational, deferred rotational and cut & carry system respectively. The productivity of legume component from different grazing system recorded in the growth period, the maximum yield (0.31 t/ha) was noticed in the cut & carry system followed by (0.23 t/ha) in deferred rotational system, (0.20 t/ha) in continuous and (0.15 t/ha) in rotational during the second year (1999). The main legume



Plate -V Lay out of quadrat for estimation of forage biomass

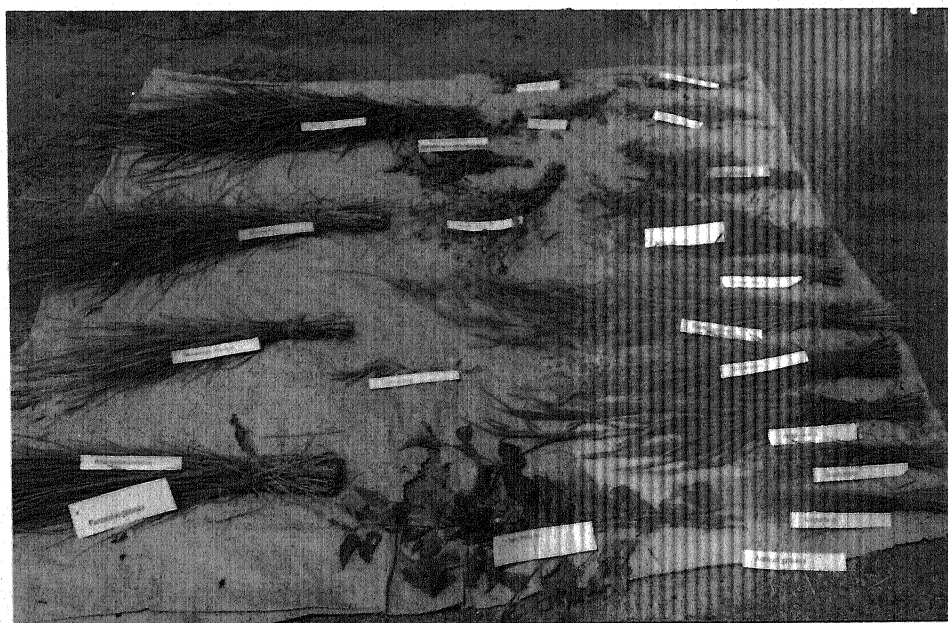


Plate-VI Sorted samples of clipped material of species and species groups for biomass

Table- 14. Species wise dry forage production (g/m²) in different systems

Species	Rotational		Deferred rotational		Continuous		Cut & Carry	
Grasses	1998	1999	1998	1999	1998	1999	1998	1999
Perennial grasses								
<i>C. ciliaris</i>	80.0	162.4	56.0	96.0	-	-	21.0	26.8
<i>C. fulvus</i>	-	-	-	-	-	-	-	32.4
<i>D. annulatum</i>	53.0	-	78.0	80.8	103.0	72.0	46.0	12.4
<i>H. contortus</i>	294.0	193.2	276.0	308.0	220.0	250.0	179.0	114.8
<i>I. laxum</i>	2.0	-	39.0	0.4	44.0	7.2	15.0	-
<i>S. nervosum</i>	167.0	310.0	158.2	99.6	222.0	105.2	152.0	32.4
Annual grasses								
<i>A. varia</i>	3.0	27.6	2.0	7.2	-	9.6	5.0	2.4
<i>B. ramosa</i>	6.0	5.2	4.0	1.6	2.0	1.6	2.0	9.6
<i>D. adscendens</i>	7.0	20.4	16.0	7.2	17.0	7.2	11.0	12.4
<i>E. pilosa</i>	8.0	0.8	5.0	0.4	1.0	2.0	-	6.4
<i>S. glauca</i>	1.0	1.2	1.0	2.8	-	8.0	1.0	3.2
<i>T. quadrivalvis</i>	-	2.8	2.0	9.2	-	0.4	-	-
Legumes								
<i>A. scarabaeoides</i>	5.0	0.8	9.0	0.4	-	0.4	18.0	3.2
<i>A. longifolius</i>	-	0.8	-	0.4	-	-	1.0	-
<i>C. pumila</i>	-	0.8	-	-	-	0.4	-	1.2
<i>C. ternatea</i>	-	0.3	-	-	-	0.1	-	0.4
<i>D. biflorus</i>	-	1.2	-	0.4	-	0.4	-	1.2
<i>I. astragalina</i>	2.0	4.4	8.0	15.2	3.0	6.8	24.0	14.8
<i>P. trilobatus</i>	-	2.8	-	2.8	2.0	2.8	3.0	2.8
<i>S. hamata</i>	19.0	0.8	4.0	2.8	-	3.6	15.0	6.8
Forbs								
<i>B. stricta</i>	-	0.8	-	0.1	-	1.2	-	2.0
<i>C. fascicularis</i>	-	2.0	-	7.2	-	6.8	-	1.2
<i>C. argentea</i>	-	2.4	6.0	0.4	3.0	7.6	5.0	12.4
<i>E. hirta</i>	2.0	0.4	3.0	0.4	3.0	0.4	-	0.4
<i>E. alsinoides</i>	-	0.4	-	-	-	0.4	-	0.8
<i>I. mauritiana</i>	1.0	-	-	0.8	-	1.1	-	0.8
<i>T. rhomboidea</i>	6.0	11.6	3.0	4.4	3.0	28.8	7.0	3.2
<i>T. procumbens</i>	-	-	1.0	-	-	-	-	-

Table- 15a. Dry forage production (t/ha) of species groups for growth period in different systems.

Species Group	Rotational		Deferred rotational		Continuous		Cut & Carry	
	1998	1999	1998	1999	1998	1999	1998	1999
Perennial Grasses	5.96	6.65	6.07	5.84	5.89	4.34	4.13	4.90
Annual Grasses	1.31	1.07	1.15	0.58	1.30	1.20	1.21	0.85
Other Grasses	0.18	0.01	0.16	0.85	0.18	0.49	0.12	0.08
Legumes	0.33	0.15	0.23	0.23	0.15	0.20	0.64	0.31
Forbs	0.12	0.22	0.15	0.16	0.10	0.58	0.13	0.24
Litter	0.22	0.31	0.27	0.19	0.36	0.28	0.26	0.19

Table-15b.Total dry forage production (t/ha) for growth period in different systems

Systems	1998	1999
Rotational	8.12	8.41
Deferred rotational	8.03	7.85
Continuous	7.98	7.09
Cut & Carry	6.49	6.57
SEm ±	0.7	1.1
CD 5%	NS	NS

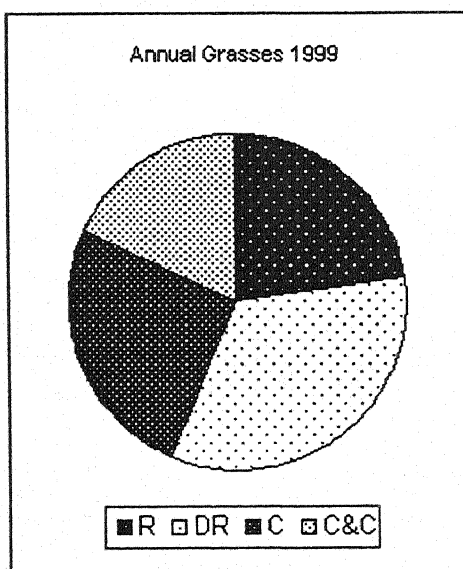
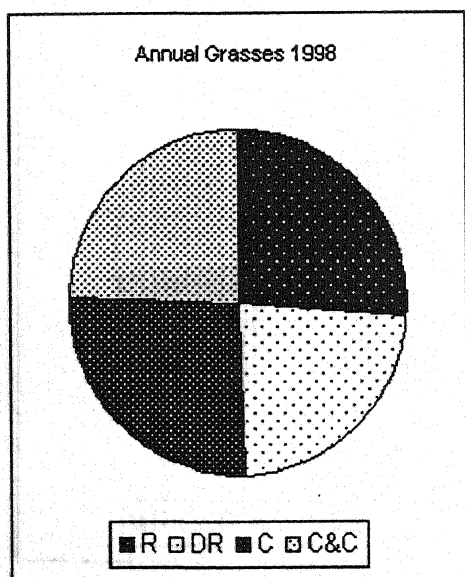
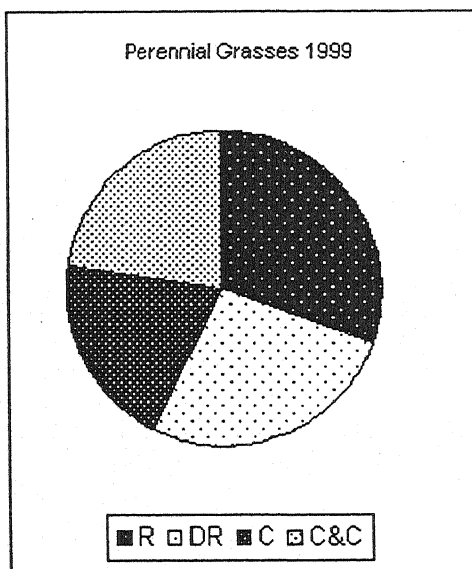
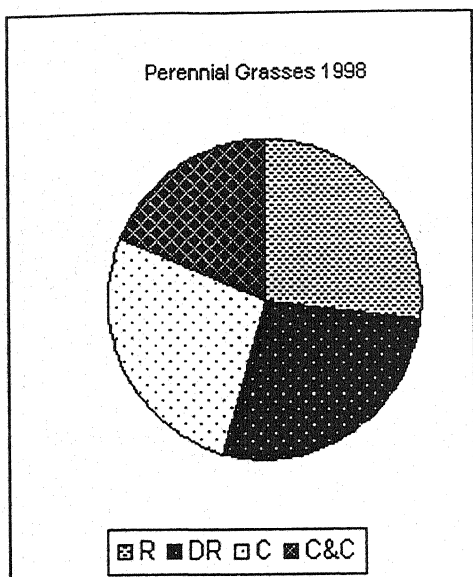


Figure-9 Biomass of perennial and annual grasses in different grazing systems

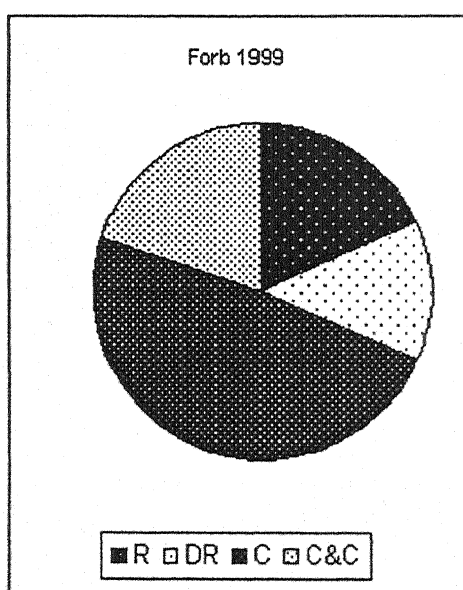
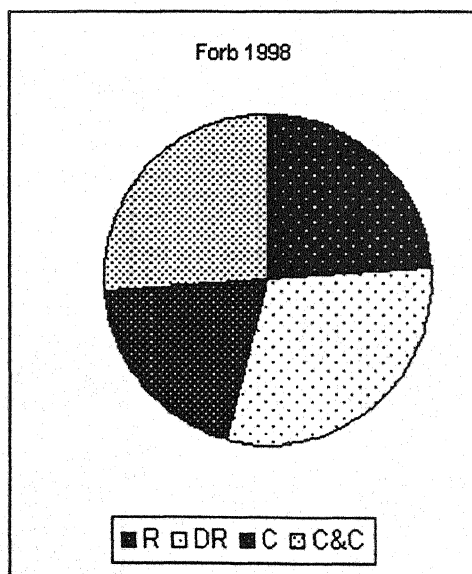
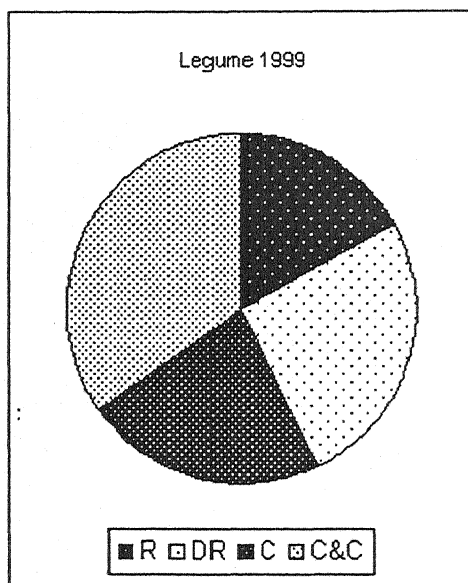
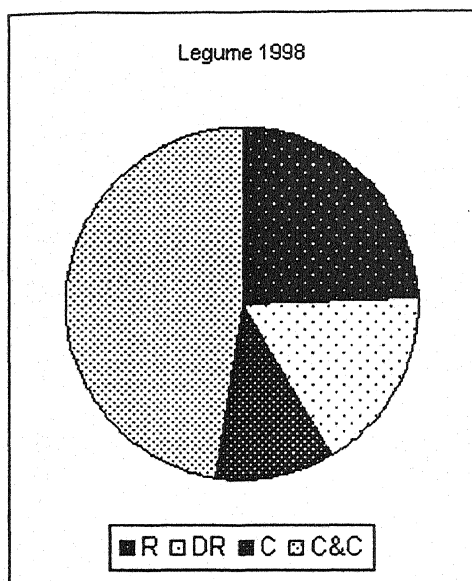


Figure- 10 Biomass of legumes and forbs in different grazing systems

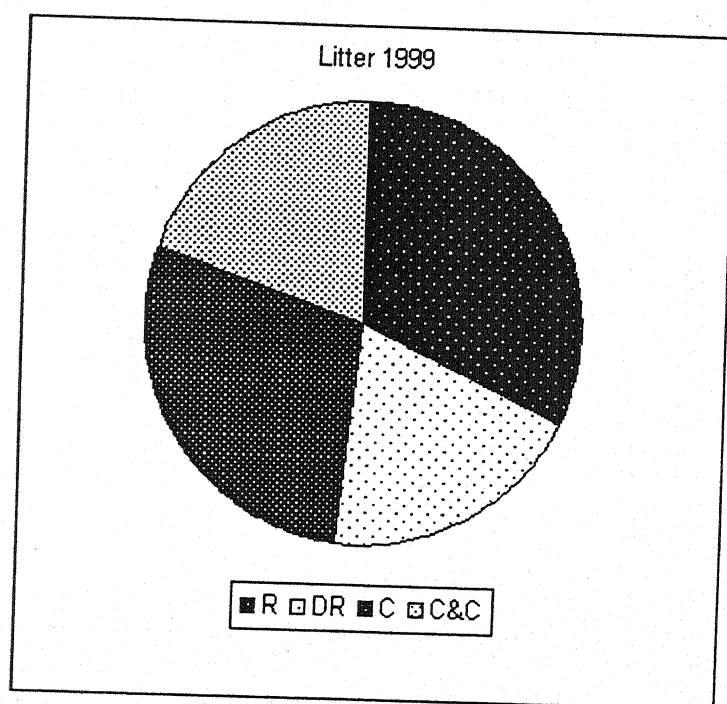
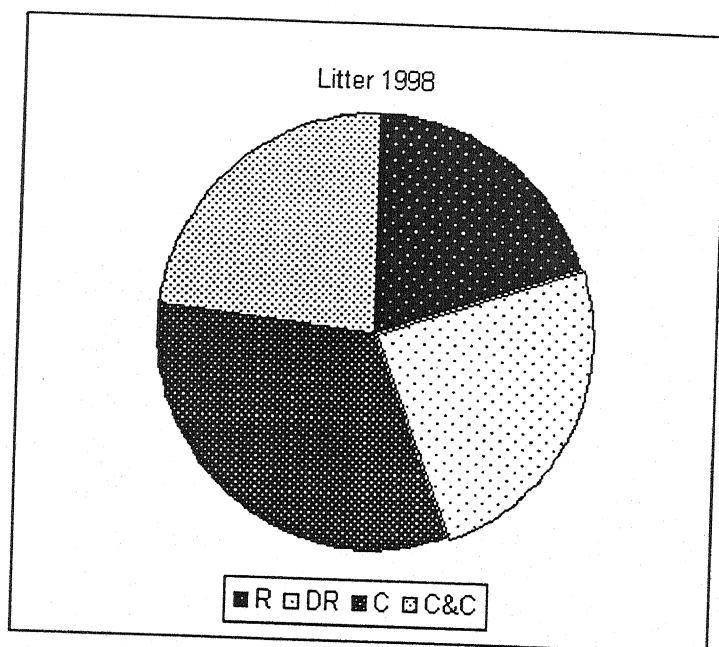


Figure – 11 Litter biomass in different grazing systems

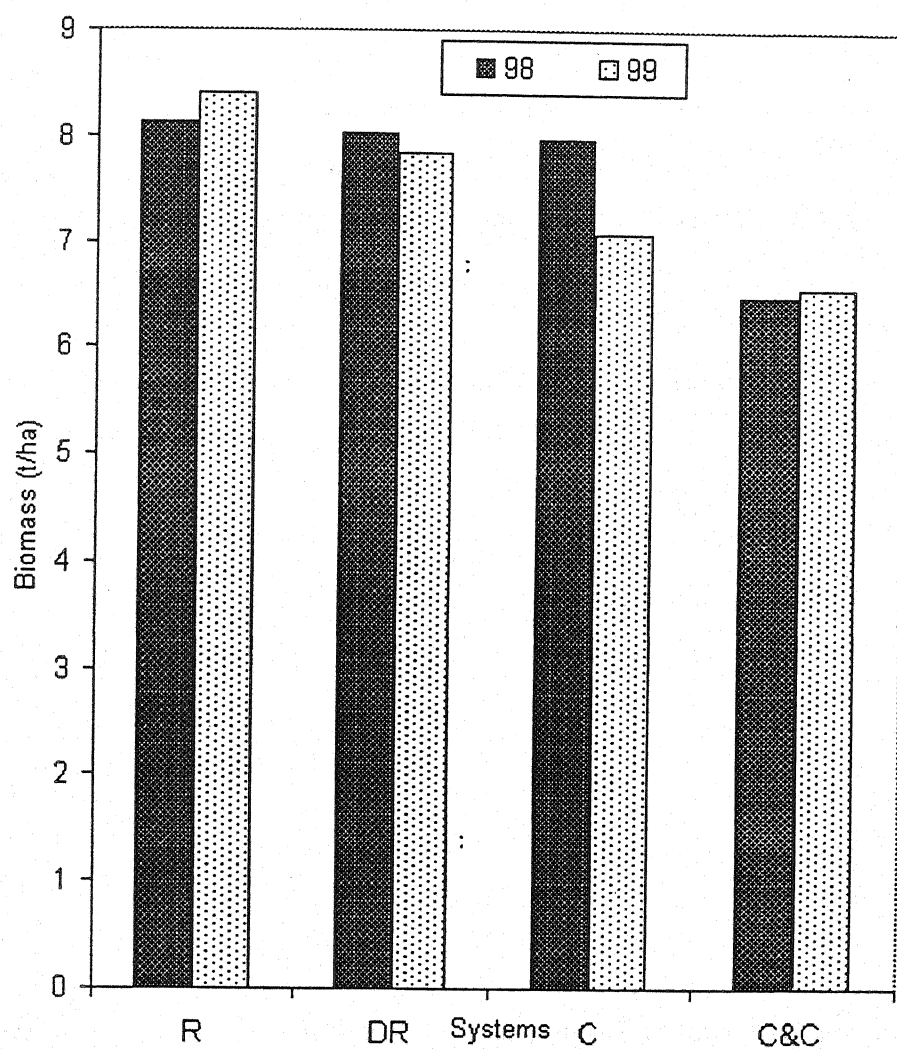


Figure-12 Total dry forage production in different grazing systems during growth period

species *I. astragalina* was contributed higher level of forage production in cut & carry and deferred rotational systems while *S. hamata* was recorded maximum (0.07 t/ha) yield in the cut & carry system when compared with other grazing systems (Table-14).

The forb component of the community registered its peak in deferred rotational (0.15 t/ha) while the lowest production was found in continuous (0.10 t/ha) in the first year while during second year the biomass of forb species ranged 0.16 to 0.58 t/ha in deferred rotational and continuous system however there were not significant differences in rotational and cut & carry system in terms of biomass (Figure-10). *T. rhomboidea* a forb species recorded maximum yield (0.28 t/ha) in continuous followed by (0.12 t/ha) in rotational system while, *Celosia argentea* contributed a higher production (0.12 t/ha) in cut & carry. *Corchorus fascicularis* was dominant in deferred rotational system.

The maximum litter 0.36 t/ha was produced in the continuous while minimum 0.22 t/ha was found in rotational grazing system in the growth period of vegetation (Figure-11). The maximum litter production in continuous system may be due to animals trampling in the paddocks. During the second year the litter production varied in different grazing systems. It was much higher (0.31 t/ha) in rotational and lower (0.19 t/ha) were recorded in deferred rotational and cut & carry system respectively. The litter produced (0.28 t/ha) in continuous system, which was lower as compared to previous year litter production.

Biomass at post growth period

The average dry forage production from different grazing systems is presented in Table-16a, 16b and Figure-14 for post growth period during the both years. An examination of Table-16b during the first year i.e. 1998 that the highest dry forage yield (7.86 t/ha) was recorded in rotational while lowest (5.16 t/ha) in continuous system, respectively. The distribution of biomass of the constituent species groups was studied in different grazing systems. It is evident from data (Table-16a) that yield from forage component was higher (7.65 t/ha) in rotational and lower (4.99 t/ha) in continuous system, while maximum litter (0.21 t/ha) produced in rotational and minimum (0.15t/ha) in cut & carry system (Figure-14). The data revealed during the second year that cut & carry system showed maximum production (6.50 t/ha) followed by rotational (6.0 t/ha)

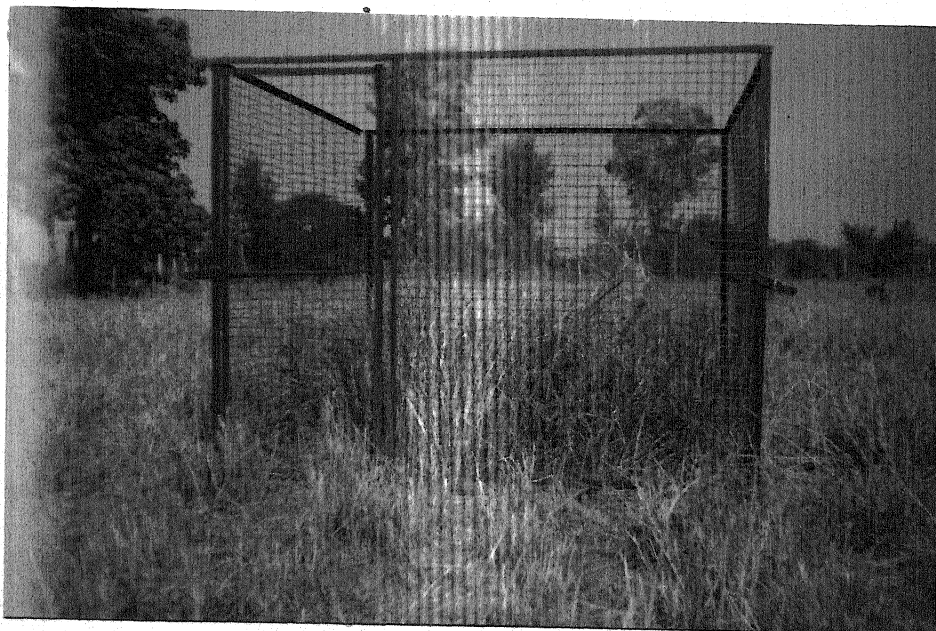


Plate-VII The growth performance of range species during post growth period



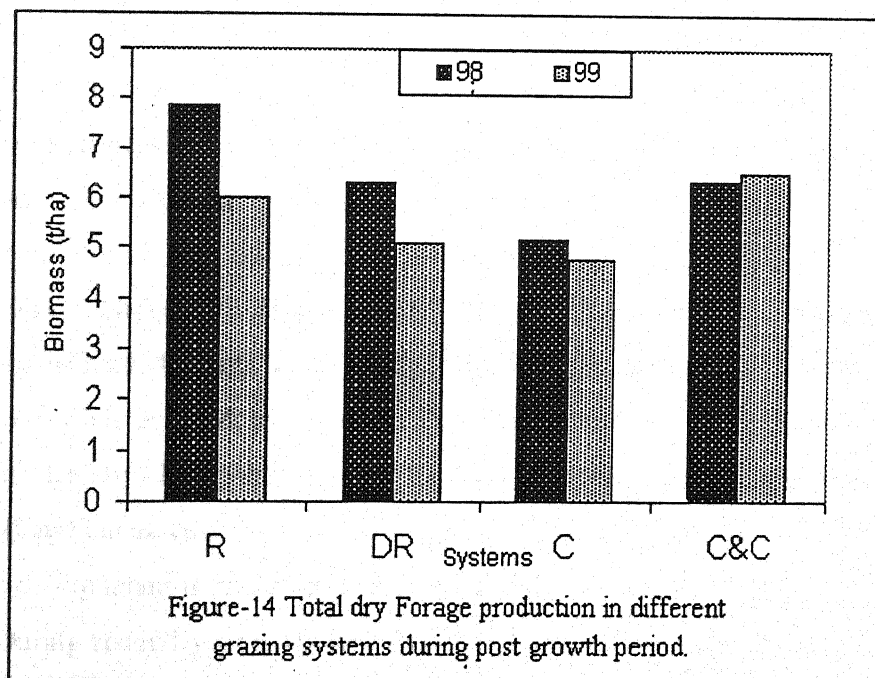
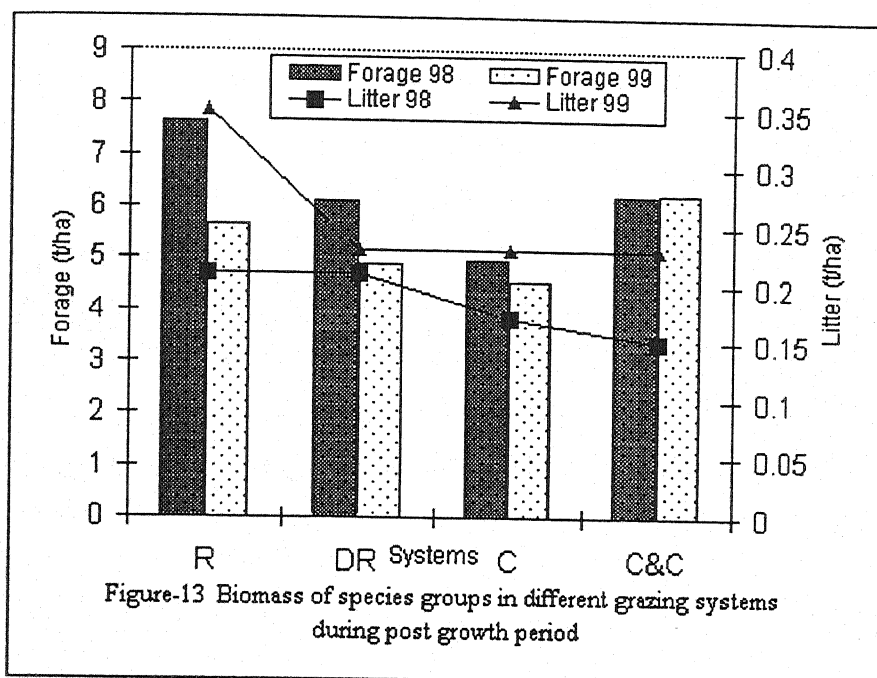
Plate- VIII Grazing during the post growth period in continuous system

Table- 16a Dry forage production (t/ha) of species groups for post growth period in different systems

Species Group	Rotational		Deferred rotational		Continuous		Cut & Carry	
	1998	1999	1998	1999	1998	1999	1998	1999
Forage	7.65	5.65	6.12	4.88	4.99	4.56	6.22	6.27
Litter	0.21	0.35	0.21	0.23	0.17	0.23	0.15	0.23

Table-16b Total dry forage production (t/ha) for post growth period in different systems

Systems	1998	1999
Rotational	7.84	6.00
Deferred rotational	6.33	5.11
Continuous	5.16	4.79
Cut & Carry	6.37	6.50
SEm \pm	0.5	0.5
CD 5%	NS	NS



and deferred rotational system (5.11 t/ha). However, minimum dry forage production (4.79 t/ha) was noted in continuous system. The productivity from different species groups of different systems was observed and found higher (6.27t/ha) forage production in cut & carry system while lower (4.56 t/ha) was recorded in continuous system. Although, maximum litter production (0.35 t/ha) was recorded in rotational system.

B. Studies on woody vegetation

Woody species are indispensable component of natural vegetation specially in grasslands. The woody vegetation of the site is comprised with shrubs and trees. All these provide fuel, timber to mankind and top feed to livestock during lean period. The studies on woody vegetation envisage species diversity, structure, composition, fuel and top feed production.

Structure

Woody species are listed in Table-17, which are categorized into trees and shrubs. The results indicated that the, during the first year of study the composition of different systems was variable. There were 19 woody species, which included 7 trees and 12 shrubs. Among trees *Butea monosperma* was most dominant species in all the systems with maximum density of 32 plants/ha in each rotational and deferred rotational system respectively, and 41 and 18 plants/ha in continuous and cut & carry systems while *Azadirachta indica* was co-dominant in all the systems. Among shrubs *Dichrostachys cinerea* was recorded as a dominant species in all the systems with maximum density of 2165, 336 and 2034 plants/ha in rotational, deferred rotational and continuous systems respectively while in cut & carry system *Ziziphus nummularia* was a dominant shrub with maximum density (218 plants/ha) and *Carissa spinarum* was co-dominant in deferred rotational and cut & carry systems. However, *Flacourtia indica* and *Z. nummularia* were found as co-dominant in rotational and continuous systems, respectively.

During second year a similar trend was observed in tree species in all the systems. *B. monosperma* was recorded as a dominant tree species with 23.5, 37.5, 39.5 and 11.2 plants/ha in rotational, deferred rotational, continuous and cut & carry systems, respectively while *A. indica* was a co-dominant in 3 grazing systems except in rotational

Table – 17. Average Density (plants/ha) of woody species in different systems.

Species Group	Rotational		Deferred rotational		Continuous		Cut & carry	
Trees	1998	1999	1998	1999	1998	1999	1998	1999
<i>A. indica</i>	10.5	5.0	9.5	6.0	5.2	4.2	7.5	6.0
<i>A. tortilis</i>	1.5	0.7	4.5	2.5	1.2	1.5	0.5	0.2
<i>A. nilotica</i>	0.2	7.7	2.7	0.2	3.7	3.5	0.5	0.5
<i>B. monosperma</i>	32.7	23.5	32.7	37.5	41.2	39.5	18.2	11.2
<i>D. sissoo</i>	-	-	1.5	1.2	-	-	1.2	1.2
<i>H. integrifolia</i>	5.2	1.5	3.2	2.7	3.7	2.7	2.5	2.5
<i>L. leucocephala</i>	10.0	4.2	0.2	-	-	-	0.2	0.7
Shrubs								
<i>A. catechu</i>	43.7	57.0	26.7	20.7	30.0	31.0	89.7	106.0
<i>A. leucophloea</i>	11.5	13.7	20.7	12.5	7.0	6.0	6.0	5.7
<i>C. spinarum</i>	119.2	114.7	157.5	114.7	89.7	85.0	211.5	363.0
<i>C. procera</i>	2.7	1.5	5.0	4.0	1.7	1.2	0.2	0.2
<i>D. cinerea</i>	2165.2	1470.2	336.7	921.0	2034.7	1527.5	83.7	67.5
<i>E. laevis</i>	31.7	18.7	8.5	3.7	12.5	6.0	20.5	20.7
<i>F. indica</i>	168.0	182.7	127.0	113.0	58.7	36.2	82.2	94.2
<i>L. camara</i>	5.2	4.2	9.7	8.0	2.0	2.0	5.5	3.2
<i>M. rubicaulis</i>	18.0	29.2	10.2	8.7	3.5	2.5	20.0	48.0
<i>S. virosa</i>	69.7	65.0	28.2	27.2	28.5	32.7	49.2	32.5
<i>Z. nummularia</i>	137.2	119.5	117.7	82.0	107.7	58.5	218.0	235.0
<i>Z. xylopyra</i>	47.0	41.7	20.7	19.5	21.0	20.5	45.5	41.0

system where *Acacia nilotica* was found a co-dominant with 7.7 plants/ha. As regards shrub component a similar trend was observed in species diversity. *D. cinerea* was found as a dominant in comparison with previous year and attained higher diversity 1470, 921 and 1527 plants/ha in rotational, deferred rotational and continuous systems respectively while *C. spinarum* was dominant with higher density (363 plants/ha) in cut & carry system. This species was a co-dominant in deferred rotational and continuous system, however, *F. indica* and *Z. nummularia* were co-dominant in rotational and cut & carry systems respectively.

Growth

The growth of woody vegetation is an important attribute as it plays important role in supplying fire wood, timber and top feed etc. The growth of different woody species were studied in the four utilization (grazing) systems in term of average number of branches / plant and diameter (cd) at the collar height. The results are presented in Table-18.

Collar diameter

The average collar diameter (cd) was measured for all the woody species in different systems and data are furnished in Table-18.

During 1998, among tree species *B. monosperma* a fuel producer attained the highest cd and the values for this were 9.1, 8.1, 7.0 and 6.4 cm respectively in cut & carry, deferred rotational, continuous and rotational system. In case of shrubs, *Ziziphus xylopyra* showed highest cd in 3 grazing systems namely rotational, deferred rotational and cut & carry with 3.8, 5.0 and 4.4 cm while in continuous system *Acacia leucophloea* achieved maximum cd (5.5 cm). In comparison to first year most of the tree species exhibited an increasing trend during second year in all the systems. *B. monosperma* attained the maximum cd i.e. 12.0, 16.7, 17.4 and 13.9 cm in rotational, deferred rotational, continuous and cut & carry systems, respectively. Among the shrubs *Z. xylopyra* achieved maximum cd in rotational (8.7 cm) and cut & carry systems (7.0cm), while *A. leucophloea* showed maximum cd in deferred rotational (8.2 cm) and continuous system (9.1 cm).

Table-18. Growth parameters of woody species in different systems.

Species	Rotational			Deferred rotational			Continuous			Cut and Carry		
	Average No. of branches / plant		Average collar diameter (cm)	Average No. of branches / plant		Average collar diameter (cm)	Average No. of branches / plant		Average collar diameter (cm)	Average No. of branches / plant		Average collar diameter (cm)
	98	99		98	99		98	99		98	99	
Trees												
<i>A. indica</i>	2.8	2.7	2.4	2.4	3.2	3.0	2.7	1.8	2.2	2.3	2.6	3.2
<i>A. tortilis</i>	0.6	-	0.6	0.5	0.9	0.6	1.5	-	1.8	-	-	-
<i>A. nilotica</i>	-	1.0	-	0.5	0.8	0.3	1.5	0.9	1.8	0.7	2.5	1.4
<i>B. monosperma</i>	3.5	4.3	5.8	3.8	12.0	8.1	3.6	4.8	7.0	3.2	3.9	9.1
<i>D. sissoo</i>	-	-	-	1.1	-	0.5	-	-	-	1.7	-	1.5
<i>H. integrifolia</i>	1.8	-	1.2	1.1	1.1	2.1	4.7	1.5	2.3	2.5	-	1.3
<i>L. leucocephala</i>	1.1	1.5	4.1	-	5.5	-	-	-	-	-	-	1.0
Shrubs												
<i>A. catechu</i>	3.0	2.5	3.4	2.5	6.9	3.5	1.5	2.2	1.8	2.9	3.9	4.2
<i>A. leucophloea</i>	1.2	2.3	1.9	2.5	5.8	3.3	2.9	2.0	5.5	2.0	1.6	2.9
<i>C. spinarum</i>	4.2	6.7	1.1	3.5	1.9	1.0	5.3	16.6	0.6	5.0	9.9	1.5
<i>C. procera</i>	1.0	-	0.3	3.0	0.1	0.9	2.0	2.3	0.4	-	-	-
<i>D. cinerea</i>	0.9	2.7	0.8	1.5	1.7	1.0	1.1	1.3	0.7	1.6	3.0	1.5
<i>E. laevis</i>	3.2	3.8	2.1	2.8	3.1	2.3	1.8	2.5	1.3	2.0	4.9	2.6
<i>F. indica</i>	5.7	8.9	1.6	4.5	2.9	2.0	5.6	6.4	1.8	3.4	11.6	1.8
<i>L. camara</i>	3.8	4.1	1.3	3.7	0.9	1.7	0.7	-	0.2	2.1	5.5	0.6
<i>M. rubicaulis</i>	3.1	4.7	1.8	1.7	3.1	1.5	0.6	-	0.4	2.0	3.1	0.5
<i>S. virosa</i>	1.6	8.5	1.5	5.3	3.3	2.0	3.8	4.7	1.1	5.2	14.0	1.6
<i>Z. nummularia</i>	4.0	11.1	1.8	4.1	3.1	1.8	5.4	8.2	2.0	3.4	14.1	1.4
<i>Z. xylopyra</i>	4.0	3.2	3.8	2.4	8.7	5.0	2.2	2.2	3.2	2.9	4.2	4.4

Average number of branches per plant

There were not much differences in average number of branches per plant in different systems. During the first year of study in *B. monosperma* maximum number of branches were found in rotational, deferred rotational and cut & carry systems with 3.5, 3.8 and 3.2 branches/plant respectively, while in continuous system the higher branches (4.7) were observed in *Holoptelea integrifolia*. The data revealed that *F. indica* showed higher branches (5.7 and 5.6) in rotational and continuous system while *Securinega virosa* exhibited higher branches (5.3 and 5.2) in deferred rotational and cut & carry systems respectively (Table-18).

During the second year, among tree species *B. monosperma* indicated similar increasing trend in all the systems and recorded maximum number of branches (4.3, 4.9, 4.8 and 3.9) in rotational, deferred rotational, continuous and cut & carry systems respectively. However, in shrub species, *Z. nummularia* attained higher value (11.1 and 14.1) of branches in rotational and cut & carry systems while, *C. spinarum* achieved maximum number of branches (13.2 and 16.6) in deferred rotational and continuous systems respectively.

Productivity

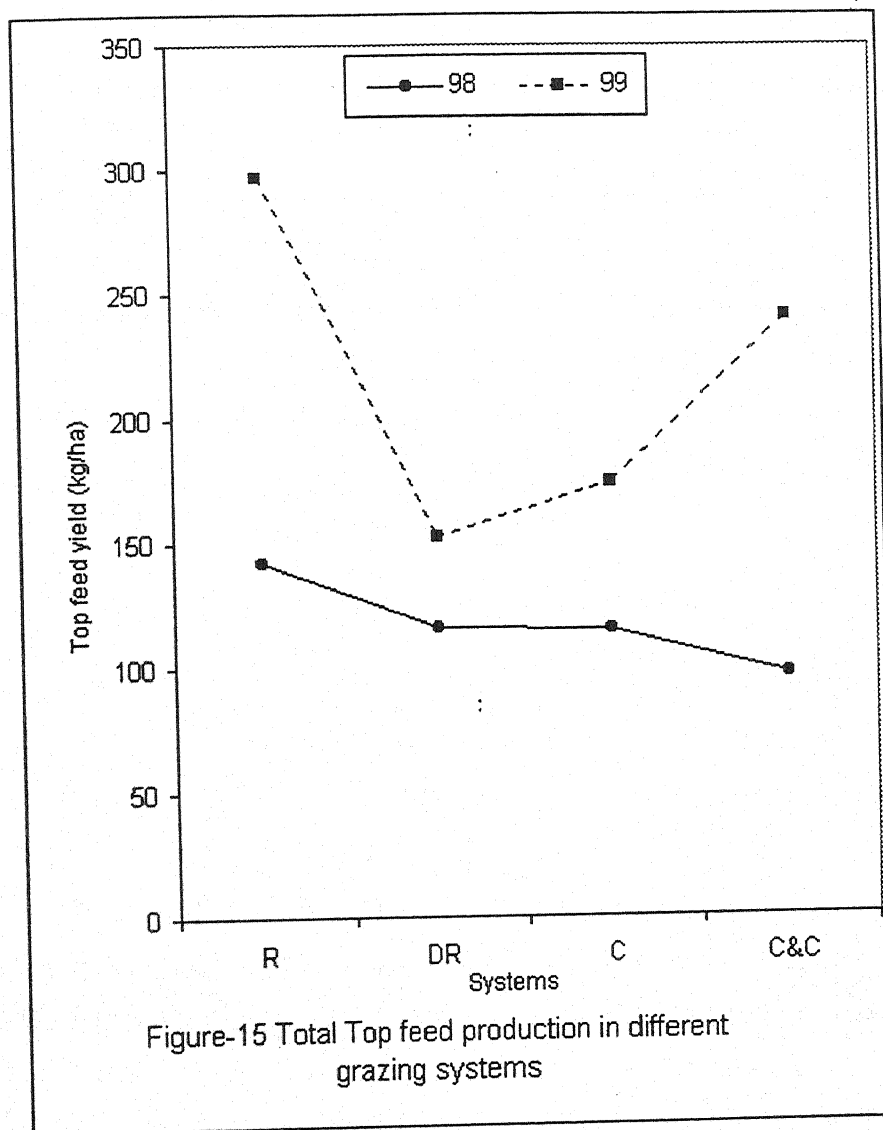
The estimation of biomass in different woody species is very important. In the present study biomass was estimated for the four grazing systems in terms of top feed and fuel wood.

Top feed production

The sun dried top feed production of different woody species in four grazing systems is shown in Table-19 & 21 for both years. During 1998 the total top feed production was maximum (142.2 kg/ha) in rotational and minimum (97.4 kg/ha) in cut & carry system (Figure-15). Among tree species *Leucaena leucocephala* and *Acacia tortilis* were main species and contributed 1.12 and 0.33 kg/ha top feed in rotational and deferred rotational systems, respectively. However, these species were not added top feed production in other systems. *D. cinerea* a shrub species, produced maximum top feed amounting to 59.2, 38.9 and 80.6 kg/ha in rotational, deferred rotational and continuous

Table-19. Top feed production (kg/ha) of woody species in different systems.

Species	Rotational		Deferred rotational		Continuous		Cut and Carry	
	1998	1999	1998	1999	1998	1999	1998	1999
Trees								
<i>A. tortilis</i>	-	-	0.33	0.07	-	0.02	-	-
<i>L. leucocephala</i>	1.12	0.11	-	-	-	-	-	-
Shrubs								
<i>A. catechu</i>	5.11	3.69	2.75	2.17	3.13	2.37	9.47	16.41
<i>A. leucophloea</i>	1.00	1.43	2.69	1.86	1.51	0.64	1.20	2.01
<i>C. spinarum</i>	34.24	20.34	36.65	17.87	11.33	5.87	31.59	89.22
<i>D. cinerea</i>	59.19	190.6	38.87	70.54	80.59	148.3	12.75	7.87
<i>E. laevis</i>	6.19	2.46	0.37	0.04	0.39	0.30	4.54	5.22
<i>F. indica</i>	16.37	37.01	17.89	26.36	8.11	2.29	12.72	19.53
<i>S. virosa</i>	7.39	7.25	1.56	3.78	3.43	1.86	4.16	2.19
<i>Z. mummularia</i>	6.37	21.79	11.60	21.31	5.13	10.08	13.94	79.50
<i>Z. xylopyra</i>	5.06	11.74	3.31	8.88	1.69	2.46	6.73	18.03



systems respectively, while in cut & carry *C. spinarum* added highest value of top feed production (31.6 kg/ha). It was next contributor woody species among shrubs in all the grazing systems.

During second year of study, the total top feed production from woody species ranged from 152.9 to 296.4 kg/ha in deferred rotational and rotational systems, respectively. A decreasing trend in top feed among tree species was observed when compared to previous year, while in shrubs *D. cinerea* exhibited an increasing trend in top feed production in all the grazing systems except cut & carry system. The higher values of top feed in *D. cinerea* were 190.6, 70.5 and 148.3 kg/ha in rotational, deferred rotational and continuous systems respectively. However in cut & carry system *C. spinarum* produced 89.2 kg/ha top feed production. *F. indica* was next contributor among shrubs and added 37.0 and 26.4 kg/ha top feed in rotational and deferred rotational system respectively, while *Z. nummularia* contributed 10.1 and 79.5 kg/ha top feed in continuous and cut & carry systems respectively.

Fuel wood production

The fuel wood production from different woody species in different systems during study period is given in Table-20 & 21. Perusal of Table-21 indicated that deferred rotational and cut& carry system produced equal fuel wood i.e. 15.9 q/ha which is followed by from rotational 12.9 q/ha and from continuous systems 11.0 q/ha. It is evident from the table that the shrub component contributed more fuel wood than tree component (Figure-16 & 17). Among the trees, *B. monosperma* was the higher producer of fuel wood in all the systems when compared with other tree species and produced 0.28, 1.03, 1.49 and 0.49 q/ha fuel wood in rotational, deferred rotational, continuous and cut & carry system respectively. However, *D. cinerea* a shrub species recorded higher production 5.54, 4.90 and 4.73 q/ha in deferred rotational, continuous and rotational system respectively, while *C. spinarum* contributed higher production of fuel wood (3.42 q/ha) in cut & carry system.

During the second year i.e. (1999) a similar increasing trend to that of first year was observed in fuel wood production of tree and shrub component. The maximum dry fuel wood yield was recorded in rotational (33.6 q/ha), followed by deferred rotational

Table-20. Fuel wood production (q/ha) of woody species in different systems

Species	Rotational		Deferred rotational		Continuous		Cut and Carry	
	1998	1999	1998	1999	1998	1999	1998	1999
Trees								
<i>A. indica</i>	0.16	0.06	0.18	0.07	0.02	-	0.07	0.14
<i>A. tortilis</i>	-	-	0.06	0.02	-	-	-	-
<i>B. monosperma</i>	0.28	0.97	1.03	2.72	1.49	1.43	0.49	0.61
<i>D. sissoo</i>	-	-	0.01	-	-	-	0.01	-
<i>H. integrifolia</i>	0.07	-	0.02	0.04	0.03	0.02	-	0.10
<i>L. leucocephala</i>	0.20	0.03	-	-	-	-	-	-
Shrubs								
<i>A. catechu</i>	0.81	1.19	0.53	0.64	0.60	0.31	2.37	4.16
<i>A. leucophloea</i>	0.26	0.22	0.19	0.31	0.13	0.09	0.11	0.19
<i>C. procera</i>	0.02	-	0.10	0.01	0.00	-	-	-
<i>C. spinarum</i>	1.74	1.26	2.17	1.58	0.69	0.48	3.42	6.42
<i>D. cinerea</i>	4.73	20.43	5.54	14.18	4.90	23.37	1.74	1.08
<i>E. laevis</i>	0.57	0.51	0.05	0.01	0.10	0.10	0.73	1.01
<i>F. indica</i>	1.35	4.36	3.09	4.12	0.80	0.58	1.74	3.00
<i>L. camara</i>	0.02	0.03	0.09	0.11	-	0.01	-	0.02
<i>M. rubicaulis</i>	0.21	0.27	0.20	0.09	-	0.01	0.64	0.27
<i>S. virosa</i>	0.87	1.65	0.38	0.61	0.71	0.51	1.23	0.46
<i>Z. nummularia</i>	0.86	1.72	1.49	2.46	0.66	0.74	2.22	6.01
<i>Z. xylopyra</i>	0.74	0.87	0.57	1.08	0.83	0.15	1.07	1.85

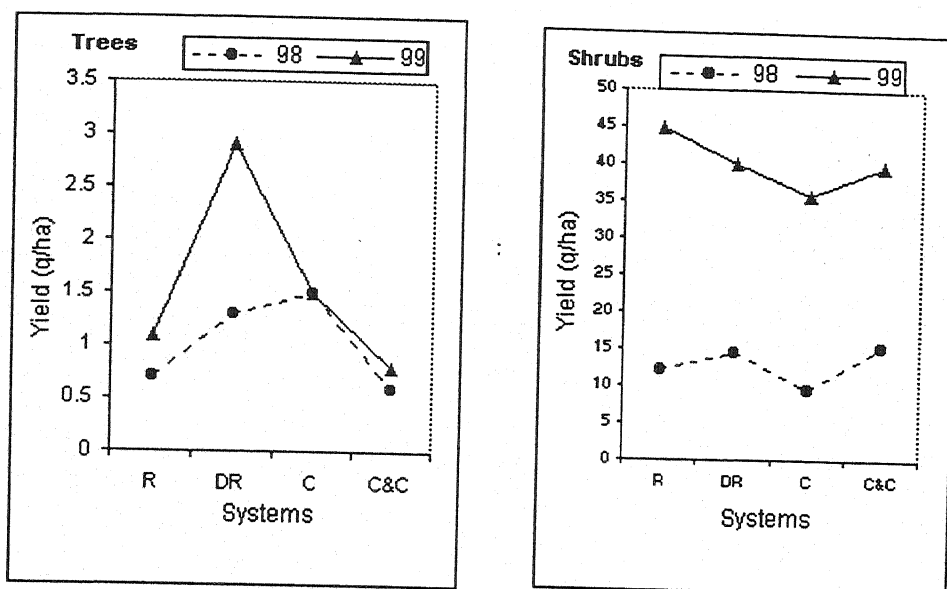


Figure-16 & 17 Fuel wood production of trees and shrubs in different grazing systems

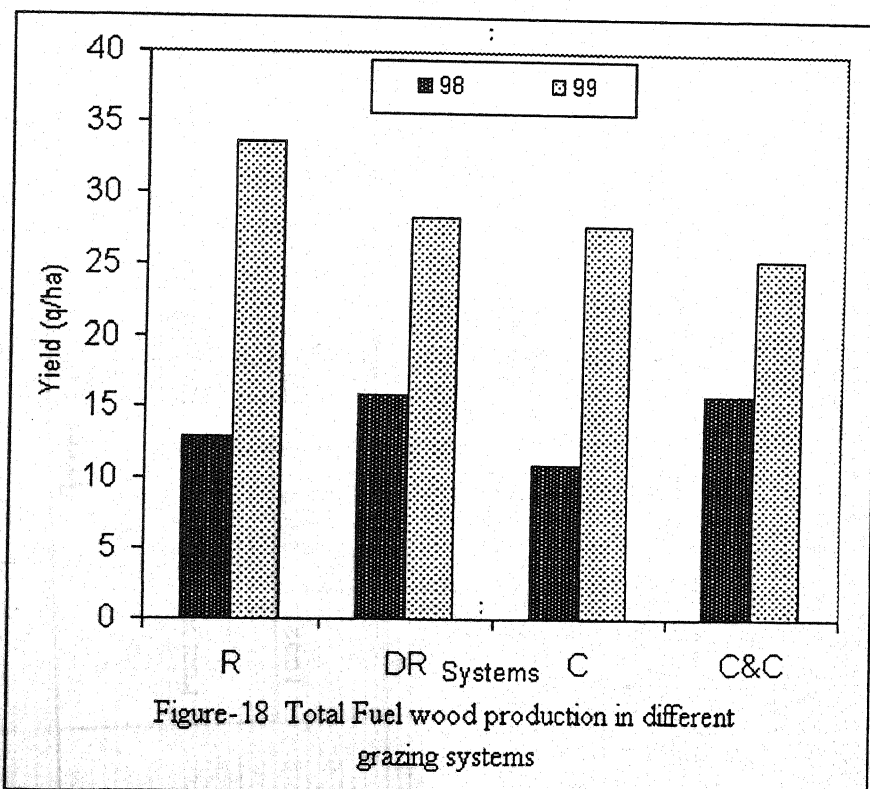


Table- 21. Fuel wood & Top feed production of trees and shrubs in different systems.

Systems	Trees				Shrubs				Total (Trees + Shrubs)			
	Fuel wood (q/ha)		Top feed (kg/ha)		Fuel wood (q/ha)		Top feed (kg/ha)		Fuel wood (q/ha)		Top feed (kg/ha)	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Rotational	0.7	1.1	1.1	0.1	12.2	32.5	141.1	296.3	12.9	33.6	142.2	296.4
Deferred rotational	1.3	2.9	0.3	0.1	14.6	25.5	115.7	152.9	15.9	28.3	116.0	152.9
Continuous	1.5	1.5	-	-	9.4	26.4	115.4	174.1	11.0	27.8	115.4	174.2
Cut & Carry	0.6	0.8	-	-	15.3	24.5	97.4	240.2	15.9	25.3	97.4	240.2

(28.3 q/ha), continuous (27.8 q/ha) and cut & carry system (25.3 q/ha) Figure-18. However, shrub component contributed more than the tree component and added maximum fuel wood yield. *B. monosperma* produced higher 0.97, 2.72, 1.43 and 0.61 q/ha fuel wood production in rotational, deferred rotational, continuous and cut & carry systems respectively. Among shrub component, *D. cinerea* recorded an increasing trend in fuel wood production and yielded 20.4, 14.2 and 23.4 q/ha fuel wood in rotational, deferred rotational and continuous system, while in cut & carry system *C. spinarum* produced 6.4 q/ha fuel wood.

C. Forage Quality

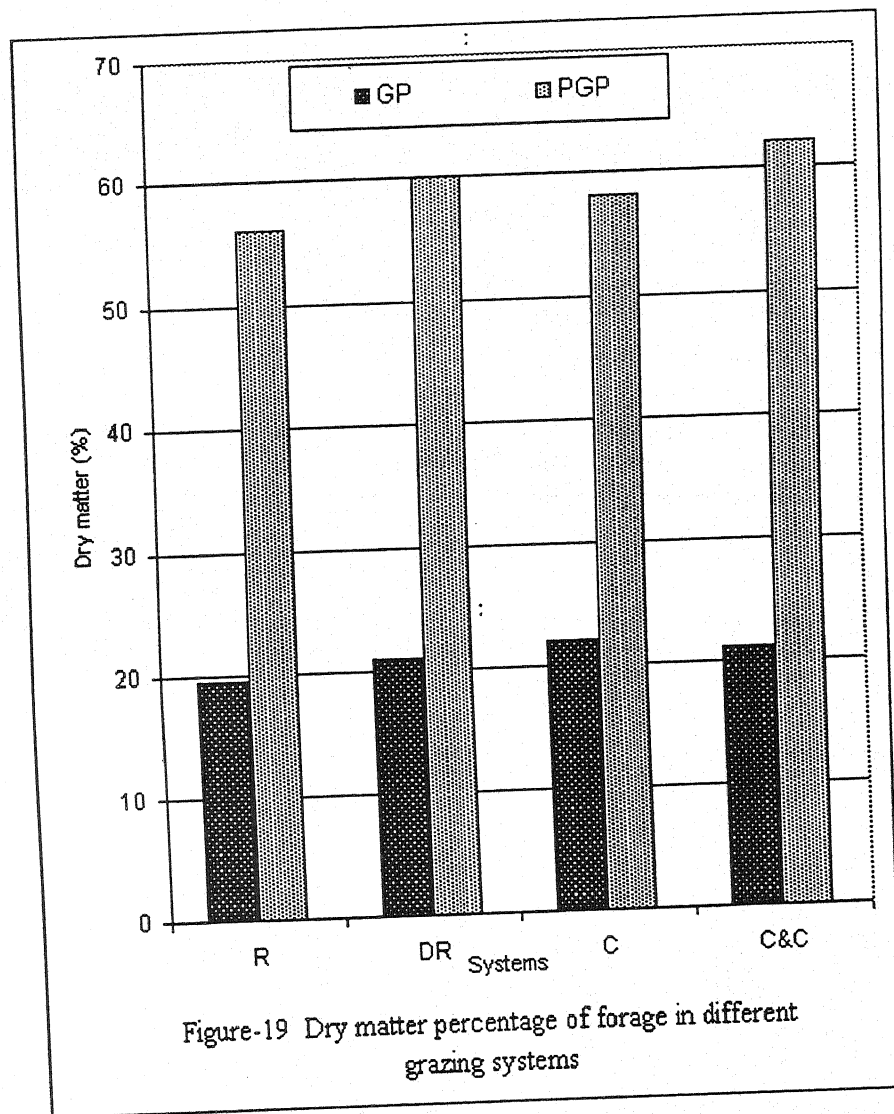
The major attributes of forage quality i.e. dry matter (DM), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analyzed in different grazing systems for both seasons viz., growth period and post growth period and are presented in Table-22.

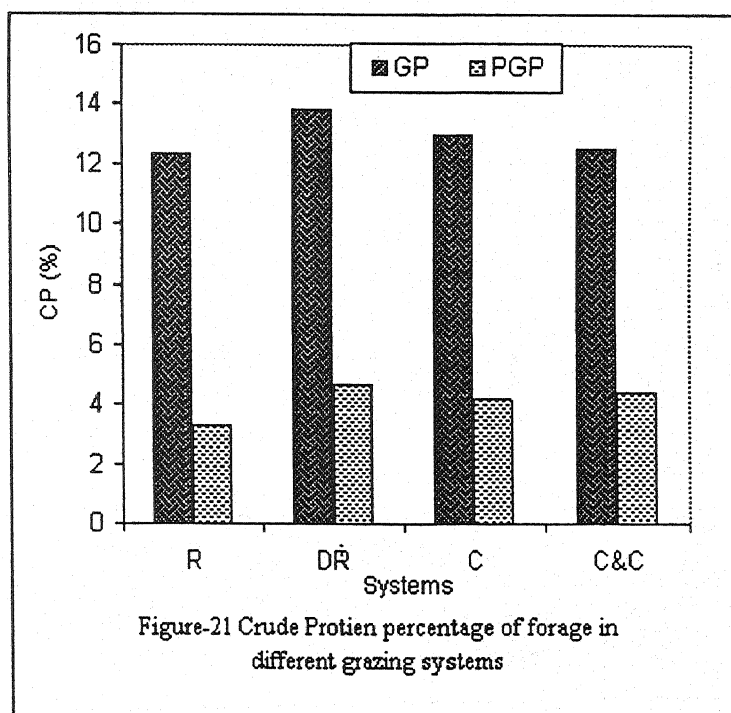
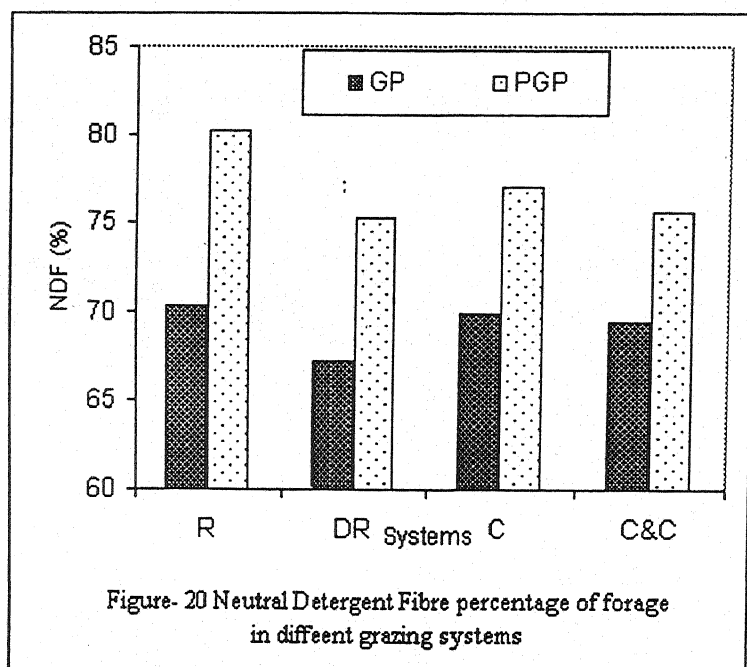
Average dry matter (DM) content of the forage was ranging between 19.5 to 22.1 % in rotational and continuous system for growth period, while 56.0 to 62.1 % was during post growth period in rotational and cut & carry system, respectively (Figure-19). The mean crude protein content of pasture ranged 12.3 to 13.8 % on DM basis in growth period and 3.3 to 4.7 % was during post growth period in rotational and deferred rotational system respectively. The CP value was significantly higher during the growth period than during the post growth period. Its concentration was reduced significant during post growth period (Figure-21).

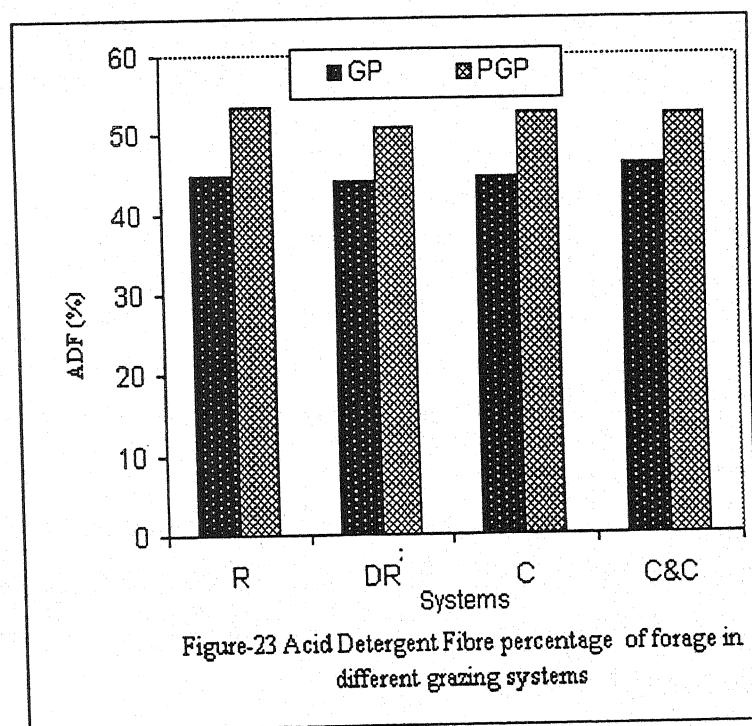
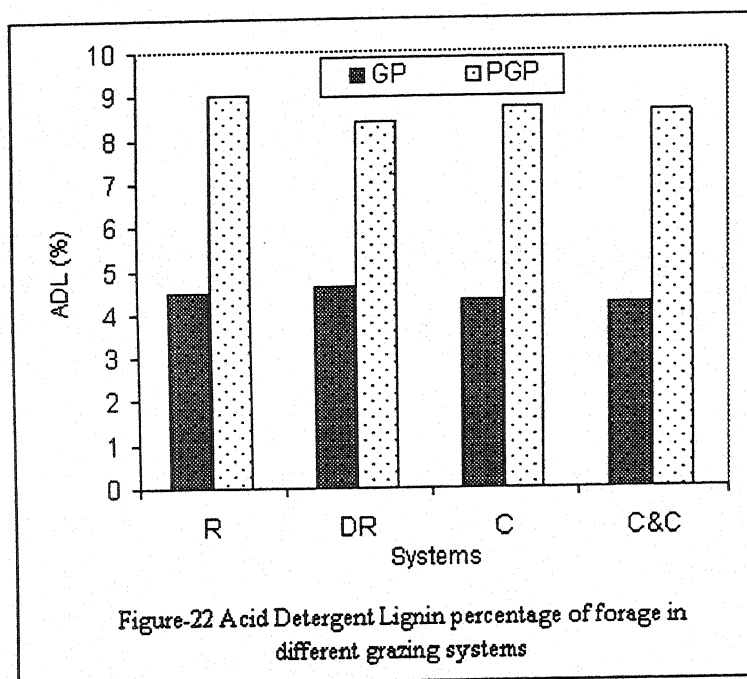
The data revealed from Table-22 that NDF % was found higher (70.3 %) in rotational while lower (67.2 %) in deferred rotational system during growth period. However, it was lower during growth period and higher during post growth period due to with maturity of pasture it was increased during the post growth period (Figure-20). ADF content of pasture was also lower during growth period and was significantly higher during post growth period. ADF % was varied from 44.1 to 46.1 % in deferred rotational and cut & carry system during the growth period while during post growth period, it was ranged from 41.0 to 53.4 % in deferred rotational and rotational system, respectively (Figure-23). ADL of pasture was found lower during the growth period and higher

Table-22. Chemical composition of forage during growth and post growth period in different systems

Characters	Rotational		Deferred rotational		Continuous		Cut & Carry	
	Growth Period	Post growth period	Growth period	Post growth period	Growth period	Post growth period	Growth period	Post growth period
DM (%)	19.5	56.0	21.0	60.1	22.1	58.2	21.2	62.1
CP (%)	12.3	3.3	13.8	4.7	13.0	4.2	12.5	4.4
NDF (%)	70.3	80.2	67.2	75.3	69.8	77.0	69.4	75.6
ADF (%)	44.9	53.4	44.1	51.0	44.5	52.8	46.1	52.5
ADL (%)	4.5	9.0	4.6	8.4	4.3	8.7	4.2	8.6







concentration was observed during the post growth period. It was ranged from 4.2 to 4.6 % for growth period and 8.4 to 9.0 % during post growth period (Figure-22).

IV. Animal Study

All the animals were maintained only on grazing from July to October and from November onward a concentrate mixture was offered to all the animals addition to grazing. The data recorded seasonally change of body weight in cattle, sheep and goat in different grazing systems during growth (July- September) and post growth period (October-December) for both years.

The changes in body weight during both periods in both years have been presented in Table-23. The body weight of cattle increased in rotational, deferred rotational and continuous systems in both years during growth period of vegetation, however, in cut & carry system the body weight of cattle was just maintained (Figure-28 & 29). During growth period the body weight recorded by cattle were 305.3, 269.3, 326.0 and 287.3 kg/cow in 1998 year, while during second year the body weights were 323.3, 276.6, 325.6 and 299.3 kg/cow in rotational, deferred rotational, continuous and cut & carry systems respectively.

In the case of sheep the body weight in all the systems increased during growth period for both years, there after body weight decreased during post growth period (Figure- 24 & 25). During first year of study the average initial body weight of sheep were 29.3, 28.8, 29.4 and 26.3 kg/sheep but during growth period, the body weight gained by sheep were 29.7, 30.8, 31.5 and 25.1 kg/sheep in rotational, deferred rotational, continuous and cut & carry systems respectively, while during post growth period the weights of sheep were exhibited in decreasing trend.

Similarly, goat maintained their body weight up to growth period in 3 grazing systems namely rotational, deferred rotational and continuous systems but goat started decreasing body weight in cut & carry system during growth period and onward the decreasing trend of body weight recorded during post growth period (Figure-26 & 27). The higher body weight (23.3 and 22.9kg) was observed in rotational and deferred rotational system while lower (21.7 and 18.7 kg) in continuous and cut & carry system respectively. During second year i.e. (1999) a similar trend of body weight was noticed during growth and post growth period in both sheep and goat (Table-23).

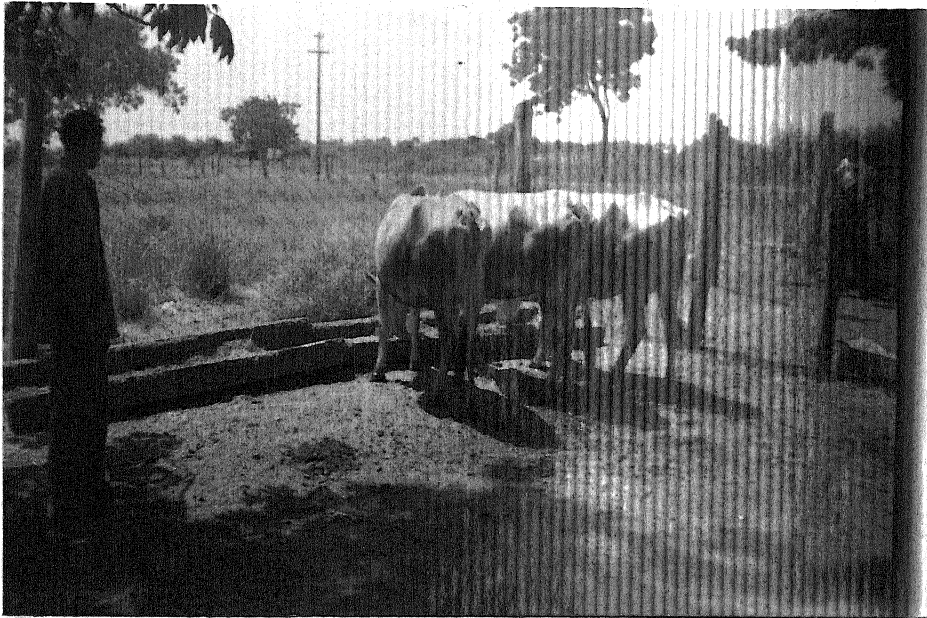


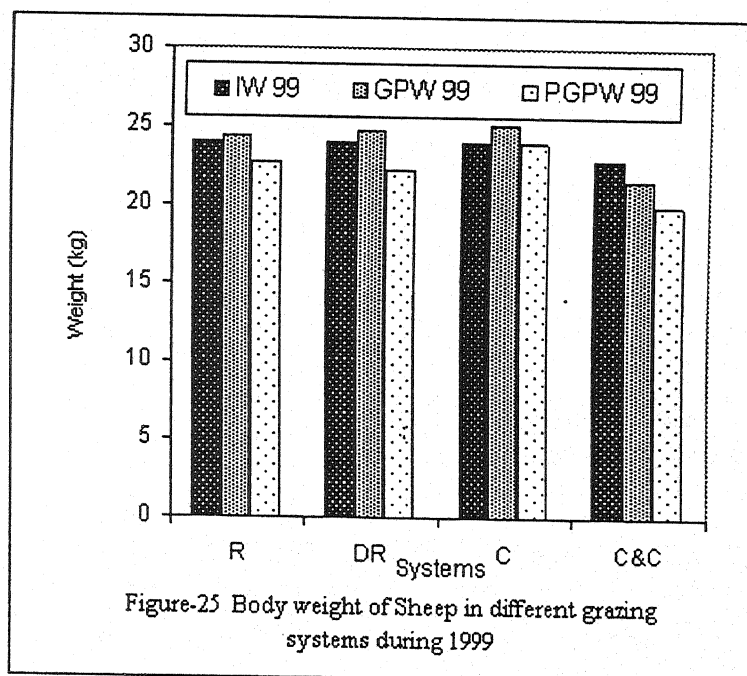
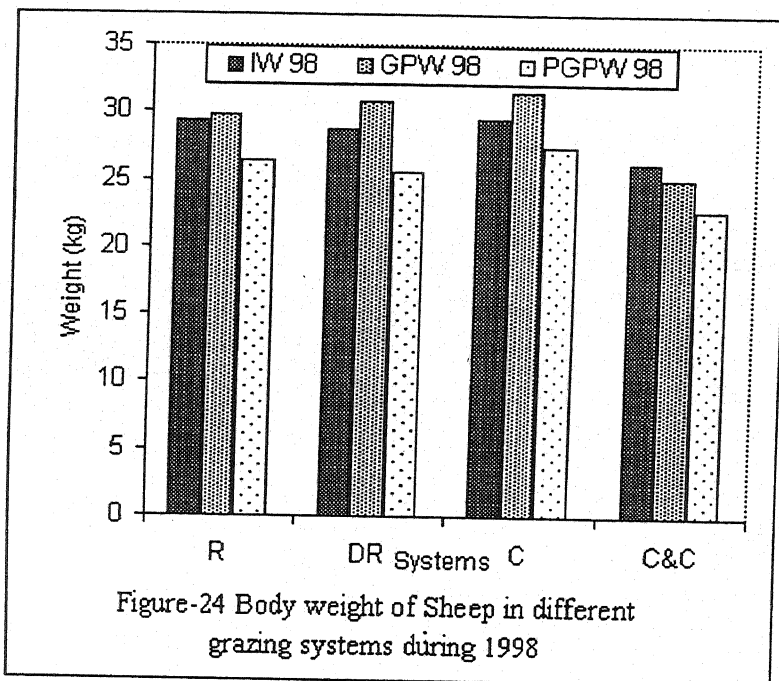
Plate-IX Stall feeding of cattle (Cut & Carry system)

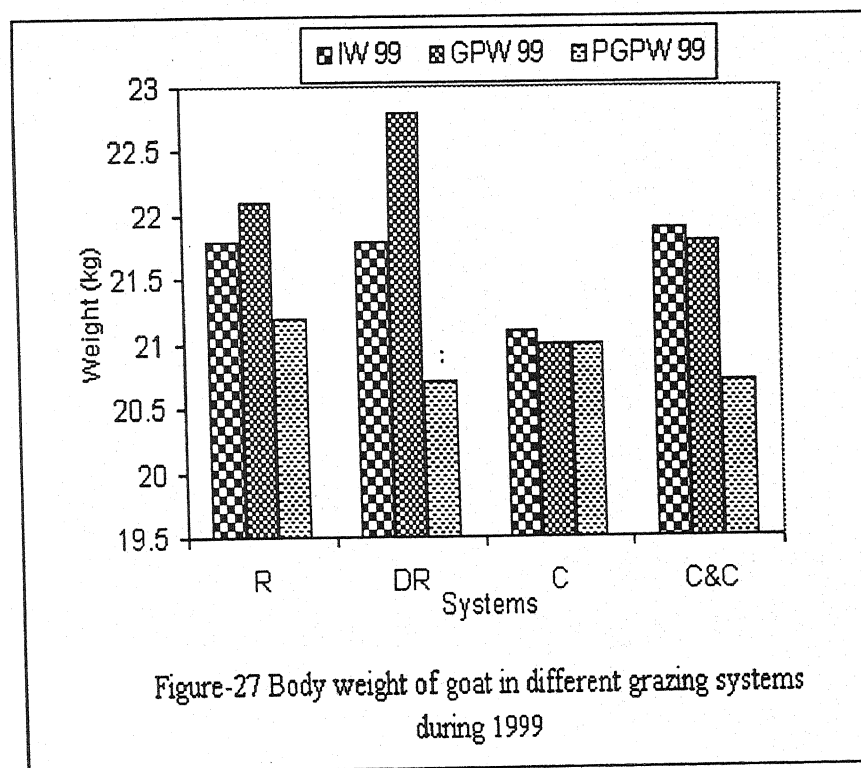
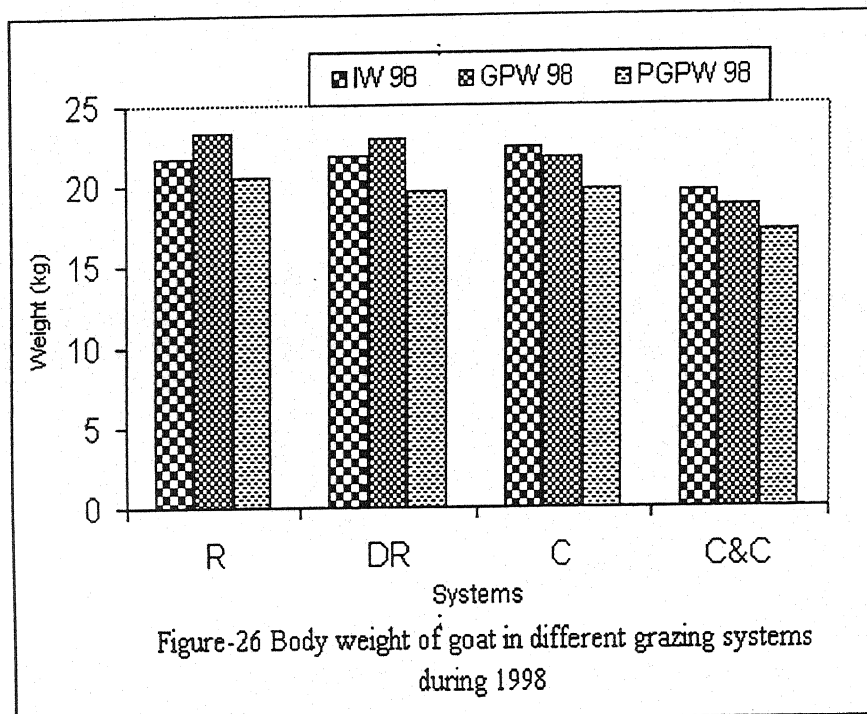


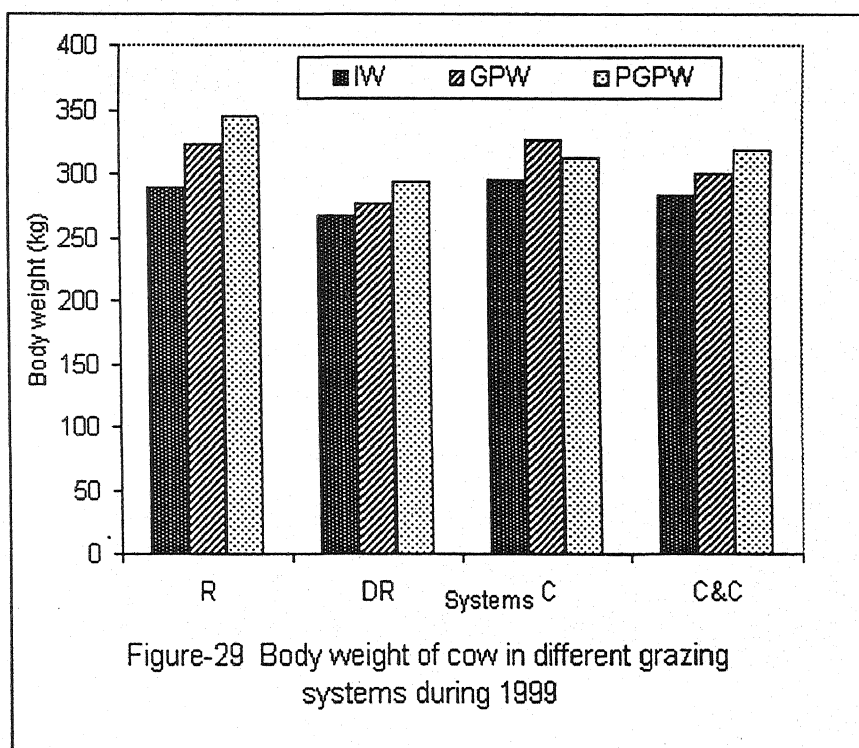
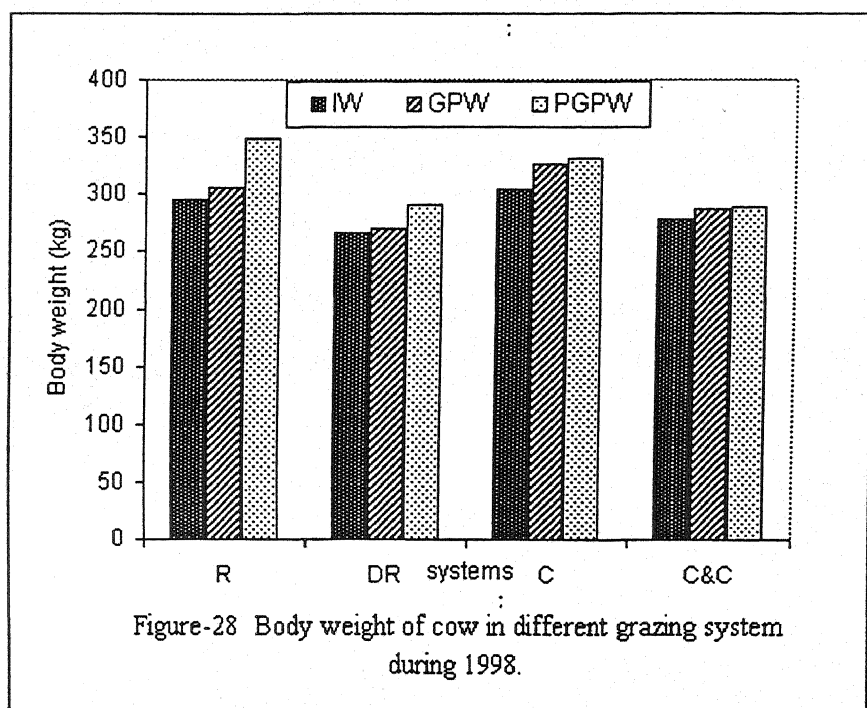
Plate-X Stall feeding by small ruminant (sheep & goat) in Cut & Carry system

Table- 23. Average body weight (kg/hd) of sheep/ goat/ cow in different systems

Systems	Initial average weight (kg)		Average weight in growth period (kg) (July-September)		Average weight in post growth period (kg) (October-December)	
Sheep body weight						
	1998	1999	1998	1999	1998	1999
Rotational	29.3	24.0	29.7	24.4	26.4	22.8
Deffered rotational	28.8	24.0	30.8	24.7	25.5	22.3
Continuous	29.4	24.0	31.5	25.1	27.4	24.0
Cut & Carry	26.3	22.9	25.1	21.6	22.7	20.0
Goat body weight						
Rotational	21.7	21.8	23.3	22.1	20.5	21.2
Deffered rotational	21.8	21.8	22.9	22.8	19.6	20.7
Continuous	22.4	21.1	21.7	21.0	19.8	21.0
Cut & Carry	19.6	21.9	18.7	21.8	17.2	20.7
Cow body weight						
Rotational	294.6	290.0	305.3	323.3	348.6	344.0
Deffered rotational	266.0	267.0	269.3	276.6	290.0	293.3
Continuous	303.3	295.3	326.0	325.6	330.6	311.6
Cut & Carry	278.6	282.6	287.3	299.3	288.0	319.0







CHAPTER - 5

DISCUSSION

Climate

It is evident from data (Table-4 & 15) that the vegetation exhibits a great diversity in the species composition and biomass production. An increasing trend between production and diversity was recorded during second year as compared to previous year. Rainfall seems to be the main cause of diversity and production. The variations are in accordance with the findings of Rai and Upadhyay (1990) as they noticed the higher productivity of herbage depending upon the amount and patterns of rainfall. Thus it would be seen that productivity is closely linked with availability of rainfall and its distribution at different sites. Rainfall directly affect on dry matter yield between different species, Rao *et. al.*, (1993) have studied the effect of low and high rainfall in *C. ciliaris* and *C. setigerus*. Similar type of relationship has been observed by Cable (1975) in the semi desert grass-shrub type on the perennial grass production. Relationship between precipitation and forage production of *C. ciliaris* in arid region at CAZRI, Jodhpur, Harsh *et. al.*, (1981) reported 82% variation in forage production accounted to

this factor. Sangakkra (1988) reported similar observation on effect of rainfall on the growth of a tropical rangeland. In his study he noticed that the productivity of these rangelands is dependant primarily on the availability of water and fertility of soil. Mertia (1991) reported similar observation in grazingland of semiarid region under rotational grazing system dominated by *Cenchrus-Aristida* grass cover, however forage production is co-related with rainfall and its distribution. Dee *et.al.*, (1966) reported the infiltration rate varied under different plant communities in soil under different successional stages. Poissonet and Deiri (1988) studied the effect of variability of rains on vegetation in protected rangelands; they concluded that the changes in vegetation attributes such as vegetal cover, density, biomass, frequency of species. Rao *et. al.*, (1993) also reported similar trends in the productivity of *Cenchrus* grass species between low and high rainfall. However the trend obtained in present study is similar to that of above h studies.

In the present investigation, the value of production depends upon solar radiation and recorded higher biomass in open than tree shade which is in conformity with the findings of several workers. Singh *et. al.*, (1980) had observed the effect of tree shade on yield in grassland planted with *A. catechu* and *D. sissoo*. They noticed that forage yield was significantly higher in open than tree shade. Similar trend has been observed by Ramakrishna (1984) and Misra & Bhatt (1990) in silvipastoral system under 13 years old *Acacia* plantation. The effect of light intensity on dry matter production in different plant species has been well established because the photosynthetic rate increased with increasing light intensities in grassland.

Soil Study

Soil moisture measurements indicated that depth and time of recording the moisture soil are important factors in controlling the distribution of plant community (Dyrness and Youngberg, 1966). The data recorded on soil moisture (Table-3) revealed that during growth period (July-September) soil moisture was found higher as compared to post growth period (October-December). In our experiment during the growth period the higher dry forage production (Table-15) indicated that moisture was the main cause for higher production in different grazing systems while in post growth period soil moisture decreased ultimately the biomass decreased. In study the effects of contour

furrow's on soil moisture conservation by Ullah Wasi *et.al.*, (1972) indicated increase in forage yield due to increase in moisture. Similar observation in botanical composition has been reported by several workers. Pandit *et. al.*, (1996) and Trivedi (1994) studied seasonal variation in species composition in grassland in relation to soil moisture. They noticed the increasing species diversity in winter season while least in summer. The results of this study indicated a relationship among these studies.

Oosting (1958) reported the structure of plant community in different conditions of soil, soil moisture and exposures. He pointed out these factors as support stands of different composition. Melkania (1988) also noticed the change of climate to induce many seasonal and inter seasonal changes in ground flora. Chinnamani (1969) has observed similar type of relationship in red soil of Hyderabad. In another such study in arid land, Sharma *et. al.*, (1997) reported that contour vegetative barriers of locally adopted in rangeland resulted over all 2.5 times increase in soil moisture storage increased yield of vegetation by 37 to 51 percent. In present study with the onset of monsoon, soil moisture increases making conditions more favorable for the growth of vegetation.

The results on soil fertility study from both years (Table-2) indicated that the four utilization systems did not show marked variations in the soil fertility parameters and can not be ascribed to the management systems this stage because of the heterogeneity among the paddocks. However, deferred rotational system was found better to other systems due to higher value of organic carbon and other available nutrients. The results of this study are related to several workers. Higher productivity has been reported by Sangakkara (1988), Dyrness and Youngberg (1966), Omaliko (1984), Odum (1971) in different climate and their effects on soil status. In arid ecosystem study by Agrawal and Kumar (1994) reported that use of on-farm residues and inclusion of legumes are some of the management practices suggested, which insure importance for sustainable production. Sharma *et. al.*, (1997) evaluated the effectiveness of contour bunds in reducing runoff and soil loss. Stroger *et. al.*, (1979) reported a good soil condition due to litter fall from shrubs. Brockman *et. al.*, (1971) have observed the effect of animals on the nitrogen status in soil under grazed and cut swards. They concluded that N fertilizer increased grass yield more on grazed sward than on cut sward. In present study, the higher

available nitrogen in deferred rotational and lower in cut & carry system have been reported (Table-2) which are also in conformity with some workers like Kanodia *et. al.*, (1993), Shankarnarayan *et. al.*, (1975 & 1976).

Plant study

(A.) Herbaceous component

Botanical composition

A total number of 33 herbaceous species were recorded at the study sites. Out of these 12 species were grasses, 9 legumes and 12 forbs (Table-5). The maximum diversity in rotational system and minimum in continuous (Table-4) may be due to microedaphic, and grazing management factors (Figure-8). For the comparison of vegetation in different sites (grazing systems), similarity index (Hanson and Churchill, 1965) was calculated. The low value of index in first year indicates less variation in vegetation. However an increasing trend in similarity index during second year may only due to ecological factors such as climatic conditions, grazing management etc. The published literature on botanical composition under different grazing systems viz., rotational, deferred rotational, continuous and cut & carry systems are scanty. The results obtained in this study confirm this that the contribution of the grasses in dry forage yield was more (80%) while diversity was lower as compared by legume and other forb species. Chaturvedi & Saxena (1992) reported the similar trend in the diversity of grazing land increased with decreasing yield of grasses in Central Himalaya.

Several reports pertaining to diversity are available. Melkania (1988) had studied that number of species was maximum in all the habitat during rainy seasons (June to September) while lower after growth period. Paulsamy *et.al.*, (1987) and Pandey (1990) reported similar observations on diversity. However they did not notice any significant differences among different grazing systems. Although the observations were co-related with present study. Rai (1997) and Pandit *et.al.*, (1996) have studied the species composition in grazing lands. They concluded similar observation on diversity.

IVI is a summation of percentage value of any three relative attributes such as dominance, composition and frequency of the species. In different grazing systems, four perennial grasses viz., *C. ciliaris*, *H. contortus*, *S. nervosum* and *D. annulatum* were

found through out the year and showed maximum IVI. Higher IVI value of these species may be ascribed to absence of other associates and different ecological factors. During the 1998, *S. nervosum* was dominant in 3 grazing systems except in rotational system and *H. contortus* as co-dominant while in second year (1999) *H. contortus* was dominant with *S. nervosum* as co-dominant in all the systems. Thus from the study two communities namely *Sehima-Heteropogon* type and *Heteropogon-Sehima* type are recognized.

Pieper (1968), Sharitz, Cormick (1973) and Vogel & Van Dyne (1966) have studied species composition in different climate and discussed similar observations. The trend in botanical composition suggested that micro climatic conditions and nutrient status had influence in determining the species diversity in different grazing system. Trivedi (1994), Sah & Saxena (1990) Prajapati *et. al.* (1975) and Trivedi & Soam (1998) have reported the phytosociological studies under different soil, water contents and found similar results.

Hyder *et. al.*, (1966) and Hazell (1967) studied the effect of grazing intensity on plant composition. They noticed an increasing trend in undesirable grasses and forbs. A similar type of relationship has been observed by Prajapati (1970) in arid region of Rajasthan. Similar trends in botanical composition under grazed and ungrazed condition have been reported by several workers. Singh and Mishra (1969) noticed the increased diversity in grazed situation whereas Ram *et. al.*, (1989) and Shankar *et. al.*, (1975) studied the increasing dominance with advancement of growing season. Rai (1997) reported no harmful effect on the composition and dominance of the perennial grasses in natural grassland due to round year grazing. Omar & Zaman (1988) have shown as inverse relationship between inside and outside enclosures. As per their calculation the percent cover of total vegetation was about 35% higher than out side. Several reports pertaining to impact of grazing in botanical composition are available. Harsh (1988), Man & Shankar (1978) and Gupta (1988) reported similar results as in this study. Pervolotsky and Hamov (1988) observed the effect of continuous goat grazing on the cover of vegetation. These results indicate the decreasing trend in vegetation cover for several years.

Vigour

In present study no definite trend was found on vigour of range grasses and legumes (Table-10,11,12 & 13) in different grazing systems. Although higher vigour of range species were found in rotational system and lower in continuous system. Perhaps this may be due to effect of grazing management system. Several reports pertaining to plant vigour under different climatic, biotic, edaphic and other ecological factors are available. Hazell (1967) found a decreasing trend in vigour under heavily grazed sites as compared to moderately grazing. Prajapati *et.al.*, (1975) reported relationship existing between plant vigour and grazing stress. They concluded that unsystematic and continuous grazing resulted into retrogression of pastures. Shankarnarayan (1977) had also reported similar results for over grazing on the grassland. Similar differences have also been observed by Pieper (1968) on grazed and ungrazed grasslands. They noticed the higher height of plants in protected areas. The effect of fertilizer applications on the aspect of vigour many workers have reported their results. Kanodia *et. al.*, (1993) discussed the nitrogen effect on basal diameter, number of tillers as well as dry forage yield. Some information on plant vigour has been discussed by Taintan (1974).

The results on effect of different grazing rotation indicate a reduced tiller density in rangeland. However, a comparison made by Eckert and Spencer (1987) on the growth of grasses with heavily grazed under rest rotation management with other system like protected from grazing on similar sites, the average basal area cover was found to be better. Negi *et. al.*, (1993) found a relationship on height of plant, to clipping or grazing. Tivedi *et. al.*, (1981) reported the similar effect of grazing on the vigour of range grasses.

Mann & Shankar (1978) observed an inverse relationship under continuous system on the vigour of some grasses in arid rangeland. As per their calculation *L. indicus* stimulate better tillering and higher plant cover under continuous grazing system. Some parameters of growth characters in some perennial grasses of this study confirm this. In present experiment among grasses *S. nervosum* and *D. annulatum* showed similar findings while among legumes *I. astragalina* and *S. hamata* exhibited higher growth parameters in continuous system. These variations in grazing systems may be due to selective action of different species of different habitats influencing the growth of vegetation.

Biomass

The higher dry forage production in rotational grazing system (Table-14 & 15) has been ascribed to varying microclimatic conditions and grazing management practices providing on these sites. The higher dry forage production (Figure-9) in rotational system of the present study was in conformity with findings of (Das and Paroda, 1980). Several workers have reported similar differences in productivity among different grazing systems. Debroy *et al.*, (1975), Joshi *et al.*, (1991) and Kumar & Joshi (1972) have studied the effect of grazing on dry matter production. They noticed the dry matter production increases with increasing intervals of grazing/clipping. The advantageous effects of grazing are brought about only when the grazing is moderate; otherwise the deleterious effects of over grazing out balance the benefits. Pandya & Sidha (1989) and Pandit *et al.*, (1990) have observed seasonal variation in plant biomass in arid and semi arid region.

The vegetation showed seasonality with maximum growth in the monsoon, which decreased in the winter and dried up in the summer. In present study the maximum dry forage production was found during the growth period and minimum in post growth period (Table-15 & 16) during both the years. Cable (1965), Hazra (1995), Debroy (1975), Horrell & Court (1965), Harsh *et al.*, (1981) have reported some information in respect of biomass production under different seasons and ecological factors. Among the environmental factors, rainfall influences the productivity during both the years. An increasing trend in productivity during the second year (1999) was due to more rainfall (Table-1 and Figure1). Pinder III (1975) has observed the effects of species removal on an old-field plant community. Removing the dominants increased the net productivity of sub ordinate species from 0.49 g/m² to 1.44 g/m².day. The increased net productivity of subordinate was due to increased productivity by almost all subordinate species.

The results obtained in this study on the aspect viz., yield from different grazing systems at different grazing sites, the maximum forage yield has been reported from rotational system during both the years. Detailed biomass study of vegetation are available from different studies such as Pandya & Sidha (1989), Pandit *et al.*, (1990), Premi & Sood (1999), Rai & Verma (1995), Shankarnarayan *et al.*, (1976), Sood &

Sharma (1994), and Shankarnarayan *et. al.*, (1977) have reported their results in a multifunctional fashion due to different edaphic and climatic condition. Legumes improved the quality of biomass through its root nodules by regulating the Nitrogen fixation. Similar results have also been reported by Singh & Shah (1991), Sood & Sharma (1994), Singh *et. al.*, (1997), Horrell & Court (1965). These results indicate that introduction of legume proved advantageous from production and quality point of view.

In the present study maximum dry forage production was found during growth period in all grazing systems while minimum was during post growth period (Figure-12 & 14). These fluctuations in biomass are due to precipitation and dryness in climate. During growth period more soil moisture: (Table-3) available to vegetation, which consequently increases the number of species in growth period. These species produced maximum biomass during the growth period. Productivity has been discussed by Pandit *et. al.*, (1990) and several workers reported similar relationship between rainy season and winter season. Similar results have been obtained by Pandya & Sidha (1989) in grazinglands of Kutch district.

In the present study the patterns of productivity under different grazing systems are co-related with grazing management practices. Several workers have reported higher forage yield in rotational and lower in continuous grazing system as found in present study. Das & Paroda (1980) reported an increase of 22 % in dry matter yield of herbage under rotational while 6.3 % increase in dry matter in continuous grazing system. Similarly, Upadhyay *et. al.*, (1971) also reported similar results. Some informations are also available in respect of higher productivity in rotational grazing, Richard & Spencer (1987), Heitchmiat *et. al.*, (1987), Mertia (1991) and Undersomedar & Naylor (1987). Similar differences on productivity have been observed by Ahuja *et. al.*, (1976), Goodloc (1969), Gupta (1997), Hazell (1967), Harsh & Yadav (1987), Joshi (1995) and Prajapati (1975). Shankarnarayan (1977), Taintan (1974) and Undersomedar (1987) studied the effect of grazing on the aspect of yield. They concluded similar results as in this study. Thus biomass of vegetation in different systems is largely determined by interaction of species, their phenological behaviour, species diversity, density, vigour, grazing management practices, microclimate, and biotic factors.

(B.) Woody component

Composition

In present study the maximum density of woody species was recorded in rotational while minimum in cut & carry system (Table-17). The composition in different systems is largely determined by different edaphic, grazing and climatic conditions. Kanodia (1988) noticed impact of grazing on seasonal changes of structural and functional attributes of rangeland vegetation in Bundelkhand region where number of species 21% higher in grazed as compared to partially protected sites. Gufa oba (1988) reported similar observations. He concluded that changes may be attributed to different hydrologic, geologic and edaphic factors. In study of goat grazing Pervolosksky and Hamov (1988) reported the effect of continuous grazing and found the decreasing trend in woody vegetation. Similar type of relationship in composition has been observed in this study. Hare *et. al.*, (1997), Parathasarathy & Sethi (1997), Rai (1997), Curll & Wilkins (1983) and Hasan *et. al.*, (1988) reported similar observations on several woody species, however they did not notice any significant difference in composition under different grazing systems. In our experiment as mentioned earlier, that rotational system induced increase in the density of woody species was evident than other grazing systems.

Biomass

It is evident from data (Table-21) that the maximum top feed and fuel wood production was recorded in rotational system and minimum in cut & carry system. The results indicated that dominance is directly related to productivity and diversity enhanced the productivity under protected condition. The published literature on productivity under different grazing systems are scanty. Most of the information on such aspects are available by some workers. Similar differences have been noticed by Pandit *et. al.*, (1996) in grazing lands at Bhavnagar and found a co-relation between diversity and productivity. Hasan *et. al.*, (1988) reported the productivity of some fodder trees and shrubs in semiarid region and found similar trend as observed in present study. Sharma & Ogra (1990) had been discussed plant-animal interaction under continuous grazing in a three

tier pasture ecosystem and estimated 72.5 q/ha forage. Pandey (1990) measured the canopy biomass in a dry tropical forest under protected and grazed plots.

The top feed production potential of plant species depends on its leaf turn over rate (Number of leaves produced per day) and their leaf area. The results obtained in this study on the aspect viz., yield from different grazing systems are closely linked with these study. The interaction of species, floristic composition, climatic condition, edaphic and biotic factors have a pronounced effect on the production of top feed and fuel wood of these woody species. In present study, the vegetation exhibited maximum growth in rotational than other grazing systems (Table-18). In multispecies communities, constituent species attain their maximum biomass in different systems. Perhaps this may be due to variations in their growth rates. This indicated that variation was more due to the seasonal effects.

The average number of branches and collar diameter showed a positive relation leads to its higher biomass production as evident by its strong correlation with plant height, stem diameter, top feed and fuel wood production. Similar differences have been noticed by Pandit *et. al.*, (1996) in grazing lands at Bhavnagar and found a co-relation between growth and productivity. The results indicated that growth is directly related to productivity and growth enhances the productivity under protected condition. The maximum top feed production in rotational system showed a definite relation with this study (Table-19). Hare *et. al.*, has also reported the similar results. The radial growth of different plant species is positively co-related with plant height, leaf number, leaf area as well as productivity. Stroger *et. al.*, (1979) studied the litter fall from shrubs and reported an increasing trend in soil status.

(C.) Forage Quality

The better quality of herbage during growth period (July-September) was due to higher CP and lower fibre contents in the forage (Table-22), while in post growth period (October-December) the herbage quality was poor being lower CP content and higher percent of fibre (Figure-20, 21, 22 & 23). Similar trend in herbage quality at different seasons have also been reported by Mojumdar & Rekib (1994), Singh & Srivastava (1988), Kanodia (1988) and Upadhyaya & Ramchandra (1990). They concluded that

crude protein content decreased from July to November onwards. The results of the herbage quality as affected by different seasons on different grazing systems corroborated the similar findings reported by several workers. Chakrawarti *et. al.*, (1970) have observed similar trends in forage quality during growth period and post growth period.

There was not definite trend in herbage quality among different grazing systems. The different trends in chemical composition suggest that microclimatic conditions and nutrient status have influence in determining the quality of different plant species. Similar results have been reported by Rai & Upadhyaya (1993) and Gupta (1997). They also found similar relationship. Similar type of relationship has been observed by Trivedi (1990) and Upadhyaya & Rai (1988). Kanodia and Rai (1981) recorded maximum forage quality during September and recommended this month as harvesting period for the respective grasses. Trivedi (1988) suggested trinnial burning for increasing the nutritive value of range species.

Animal Study

It is evident from data arranged in Table-23 that the body weights of cattle, sheep and goats were higher during growth period (July-September) as sufficient quality forage is available during this period, while their body weight decreased slightly during post growth period (October-December) which may be due to poor quality forage. Similar type of relation ship has been observed by Rai and Upadhyaya (1990).

The higher rate of biomass production occurred in growth period of vegetation earlier pointed out due to soil moisture, making condition more favorable for growth of vegetation. By this time, annuals germinate and perennials increase in number either by sprouting of propagules or germination of their seeds. The similar trends have been reported by several workers such as Richard & Spencer (1987), Suijcar *et. al.*, (1987), Gupta (1988), Perevolovsky & Hamov (1988), Trivedi (1988), Harsh (1988) and Joshi *et. al.*, (1991). Detailed study of botanical composition during grazing are available from different studies viz., Parthasarathi & Sethi (1997), Harsh (1988), Sangakkara (1988), Omer & Zaman (1988), Kanodia (1988), Trivedi *et. al.*, (1981) and Mann & Shankar (1978). They noticed the different trends under different grazing systems on account of different edaphic and climatic conditions. However, if comparison is made with other

grazing systems, the species diversity was higher in rotational grazing system which may be due to grazing management practice.

Several reports pertaining to botanical composition in rotational grazing system are available. Ram *et. al.*, (1989) and Phillippi (1998) found good effect of this management system, which has special feature that are distinguishing. Similar results have also been reported by Shankarnarayan *et. al.*, (1981) and Ahuja *et. al.*, (1974). The results indicate that rotational grazing system is better in comparison to other grazing management systems. Some studies on assessment of total productivity under different grazing systems are available. Upadhyaya *et. al.*, (1971) reported the superiority between rotational and continuous grazing system. They concluded that rotational grazing system is better than continuous system as the earlier system provided higher quality forage and more number of grazing days.

The published literatures on productivity under different grazing systems are scanty. Omar & Zaman (1988), Joshi *et.al.*, (1991), Phillippi (1988), Sant & Pandey (1988), Meenakshisundervalli & Paliwal (1997), Singh & Srivastava (1988), Chang xiaochuan *et. al.*, (1988) and Smith (1988) have reported the similar results under different grazing systems on the productivity of grassland in different climatic conditions. Melkania & Tandan (1985), Ambasht (1988), Manoharan & Paliwal (1988), Kanodia (1994), Das & Paroda (1980) and other several workers also found similar results on grazing impact in tropical grassland.

The results obtained in this study indicate that in goat and sheep (Figure-24, 25, 26 & 27) the body weight was higher during the growth period (July-September) and less during post growth period. However, no remarkable difference was observed with respect to body weight in cattle during growth and post growth period in different grazing systems (Figure-28 & 29) due to the age effect of cattle. The detailed studies in body weight recorded during different seasons are available from different studies. Upadhyaya & Rai (1988) reported the higher body weight during July –October but from January-June the body weight lost gradually. Similar type of relationship has been observed in study of Patnayak *et.al.*, (1988), Singh & Shankar (1994). Higher body weights during growth period have been reported by several other workers such as Mittal *et.al.*, (1988), Kanodia (1994), Arora & Swain (1988), Smoliak (1968) and Singh & Srivastava (1988).

Mittal (1988) and Harsh & Yadav (1987) have observed a significant effect on body weight in sheep and goat during October and June.

Taking the body weight of cattle into consideration, we found over all higher rate in three systems namely, rotational, deferred rotational and continuous systems while slightly higher in cut & carry system which may be due to the effect of grazing management system (Table-23). Kanodia (1994) and Yadav *et.al.*, (1998) reported similar observation, however, they did not notice any significant difference under different grazing systems. Good loc (1969) has discussed the short duration high intensity grazing period just as important to range improvement as the rest period.

CHAPTER - 6

Summary and conclusion

The present investigation entitled “Vegetation dynamics of a grassland ecosystem under four utilization patterns” was conducted in an improved grassland of about 16 hectare area at Network Collaborative Programme site of Indian Grassland and Fodder Research Institute, Jhansi (U.P.) India during the June 1998- May 2000. For this four grazing systems namely rotational, deferred rotational, continuous and cut & carry systems were considered. The study was planned with following objectives:

- (1.) To assess the influence of different grazing systems on structure, composition, growth and productivity of herbaceous plant component as well as woody component.
- (2.) To identify the best grazing system among four grazing systems for the sustainable production.

The main findings of the present investigation carried out during study period are summarized below:

- Soil pH was 6.30 to 6.35 and organic carbon ranged from 0.50 to 0.58 percent during both the years.
- Highest moisture content was found in rotational and least moisture content in continuous system during the growth period at both the depths. During the post growth period maximum moisture was noticed in deferred rotational grazing and minimum in continuous grazing system.
- During first year the available nitrogen was maximum (205.0 kg/ha) in deferred rotational and minimum (185.7 kg/ha) in rotational, while during second year the maximum (217.0 kg/ha) value of the nitrogen was found in deferred rotational and minimum (180.5 kg/ha) in cut & carry system.
- The highest value of phosphorus content was recorded in deferred rotational and lowest in continuous during both the years.
- The available potassium ranged from 160.8 to 172.0 kg/ha under continuous and deferred rotational for the year 1998 while the status of potassium during 1999 was from 158.0 to 185.5 kg/ha in cut & carry and deferred rotational systems, respectively.
- Total 33 herbaceous species were listed from the sites. There were 12 grasses (6 perennial and 6 annual), 9 legumes and 12 forbs.
- In the first year of study (1998) the total number of species were maximum (24) in deferred rotational and minimum (19) in continuous system while during the second year maximum number of species (26) were found in rotational and cut & carry system and minimum (24) was in deferred rotational system.

- During the first year *S. nervosum* was dominant in three systems namely deferred rotational, continuous and cut & carry system while *H. contortus* was co-dominant, where as in rotational system *C. ciliaris* was dominant with *H. contortus* as co-dominant. In the year 1999, *H. contortus* was dominant in all the four systems while *S. nervosum* was co-dominant in three systems except deferred rotational system where *C. ciliaris* was co-dominant.
- *C. ciliaris* was recorded higher IVI (73.6) in rotational system during the first year while *H. contortus* showed higher IVI (64.1) in continuous system in the preceding year. Among legumes *I. astragalina* achieved maximum IVI in cut & carry system in both the years, however *T. rhomboidea* a forb species attained highest IVI in cut & carry and deferred rotational systems during the first and second year, respectively.
- Grasses showed higher vigour in the rotational system and lower vigour in continuous system. Among legumes *I. astragalina* was found more vigorous in rotational but its vigour was poor in continuous during both the years. However, in case of *A. scarabaeoides* maximum vigour was observed in rotational system in the first year while higher value of vigour was found in deferred rotational system in consecutive year (1999).
- The total maximum dry forage production was recorded in rotational and minimum in cut & carry system at growth period during both the years. The grass component was main producer in all the systems. Legume component produced maximum forage (0.64 t/ha) in cut & carry and minimum (0.15 t/ha) in continuous system in the first year while during the second year maximum legume yield (0.31 t/ha) was found in cut & carry and minimum (0.15 t/ha) in rotational system.
- The forb component registered higher production in deferred rotational and lower in continuous in the first year while during second year maximum yield

(0.58 t/ha) from forb species was in continuous and minimum (0.16 t/ha) in deferred rotational system.

- The maximum (0.36 t/ha) litter was produced in continuous and minimum (0.22 t/ha) was found in rotational in first year while it was much higher in rotational and lower in deferred rotational and cut & carry system as compared to previous year.
- During the post growth period, highest dry forage yield was recorded in rotational and lowest in continuous in first year i.e. 1998, however, cut & carry system showed maximum production and minimum yield was recorded in continuous system during the second year.
- Herbage quality was found better during growth period as compared to post growth period. The CP content was maximum in growth period while minimum in post growth period. There were not much differences in forage quality under different grazing systems. However, in deferred rotational system better quality of forage species was recorded.
- The studies on woody component revealed that total 19 species were recorded which included 7 trees and 12 shrubs. The total density of woody species was recorded maximum in rotational and minimum in cut & carry system during both the years. Among trees, *B. monosperma* was dominant in all the systems while *D. cinerea* a shrub species was recorded higher density in rotational, deferred rotational and continuous system during both the years. In cut & carry system *Z. nummularia* achieved maximum density during the first year while *C. spinarum* was found as dominant in consecutive year (1999).
- *B. monosperma* had highest collar diameter (cd) among trees and *Z. xylopyra* a shrub species also exhibited higher cd as compared to other shrubs during

both the years under different grazing systems. There were not much difference in average number of branches per plant in different systems.

- Maximum total top feed production was found in rotational system during both the years, while minimum was in cut & carry and deferred rotational during the first and second year of study, respectively. *D. cinerea* produced maximum top feed of the total top feed production in 3 systems except cut & carry system.
- The fuel wood production was found maximum in deferred rotational and minimum in continuous system during the first year, however, it was higher in rotational and lower in cut & carry system in preceding year i.e. (1999).
- The body weight of sheep and goat was higher at growth period of vegetation while lower at post growth period during both the years under different grazing systems. In case of cattle, increasing trend in body weight was observed in both the seasons during both the years in different grazing systems.
- Among grazing systems least body weight gain was found in cut & carry system while higher body weight was recorded in rotational system in all the animals (sheep, goat and cattle) during both the years.

In view of above findings the present study has brought out the full information of scientific and practical significance in relation to vegetation structure, composition, growth, quality, productivity and animal performance under different grazing systems. The useful knowledge obtained about the biotic and abiotic characters gathered through this study would definitely be helpful to the farmers, researchers, foresters, agroforesters and planners for deciding the suitability of these grazing systems for a given situation.

Although, these grazing systems showed better performance in some parameters but differed in their structure, growth and productivity. Based on the overall structure, growth, biomass production, herbage quality and body weight gain in animal, the rotational system appeared to be better than other grazing systems under semi-arid condition.

BIBLIOGRAPHY

- A.O.A.O. 1988. Association of official Analysis Chemists: changes in official methods of Analysis, Arlington, USA, 71.
- Agrawal, R.K. and Kumar Praveen. 1994. Availability and management of nitrogen in soils of Arid Ecosystem. *Ann. of Arid zone*, 33(1): 1-18.
- Ahuja, L.D., M.K. Vishwanathan, K.K. Vyas and Kundan Lal. (1974). Growth of sheep of chokla breed under different systems of grazing on rangelands in the arid zone of Western Rajasthan. *Annals of Arid Zone*, 13: 259-265.
- Ahuja, L.D., S. Ramalingham, M.C. Prajapati and R.D. Bharadwaj. (1976). Range management studies: Effect of different intensities of grazing stress on forage production in *Lasiurus-Aristida* rangeland in arid zone. *Trop. Ecol.* 17 (1): 1-8.
- Ahuja, L.D. 1978. Effect of different intensities of grazing stresses in production of *Cenchrus-Aristida* rangeland in the arid zone of India. *Ann. Arid Zone* 17: 75-91.
- Ambasht, R.S. 1988. Productive structure of Vindhyan grasslands in relation to grazing. In: P. Singh, Vinod Shankar and A.K. Srivastava (eds.) IIIrd International Rangelands Congress (I): 59 p.
- Anderson, E. W. 1967. Rotation of deferred grazing. *J. Range Management*. 20 (1): 5-8.

- Anderson, E.W. 1967. Grazing systems as methods of managing the range resources. *J. Range Manag.* 20(6): 383-388.
- Arora, C.L. and N. Swain. 1988. Relative performance of sheep and goats under rangeland management systems. In: P. Singh and P.S. Pathak (eds.). *Rangeland Resources and Management*. RMSI, IGFRI, Jhansi. 436-442 p.
- Braun-Blanquet, J. 1932. *Plant sociology: A study of plant communities*. Mc Graw-hill Book Co. Inc. Newyork and London, 439 p.
- Brockman, J.S., C.M. Rope and M.T. Stevens. 1971. The effect of grazing animals on the nitrogen status of grass swards. *J. Brit. Grassl. Soc.* 26: 209-212.
- Bruinzel, L.A. 1991. Nutrient input-output budgets of tropical forest ecosystem: A review. *Journal of Trop. Ecol.*, 7: 1-24.
- Cable, W.R. 1975. Influences of precipitation on the perennial grass production in the semi-desert southwest. *Ecol.* 56(4): 981-986.
- Chakravarti, A.K., Ram Ratan and Singh, K.C. 1970. Grazing studies in the Arid and Semi-arid Zones of Rajasthan. Utilization of vegetation cover, grazing behavior of sheep and seasonal variation of crude protein content of plants in different pasture. *Ann. Arid Zone*, 9: 10-16.
- Chang xiachuan, Cai Weiqi and Xuqi. 1988. Effects of grazing on soil-vegetation system and the use of grassland by herbivorous animals. IIIrd International Rangeland Cong. (2): 328-329 p.
- Chaturvedi, O.P. and Saxena, A.K. 1992. Composition, yield and diversity of grazing land vegetation under Chir pine forest in Central Himalayan. *Range Mgmt. & Agroforestry*, 13 (1): 97-106.

- Chinnamani, S. 1969. Natural grassland (kanches) of red soil of Hyderabad. *Ann. Arid Zone*, 8(1): 66-72.
- Cunningham, R.K. 1963. The effect of clearing a tropical forest soil. *J. Soil Science* 14: 334-345.
- Curl, M.I. and R.J. Wilkims. 1983. The comparative effect of defoliation, treading and excretion on a *Lolium perenne* pasture grazed by sheep. *J. of Agric Science. Cambridge* 100 : 451-460.
- Curtis, J.T. and Mc Intosh, R.P. 1950. The interrelations of certain analytic and synthetic phytosociological characters. *Ecol.*, 31: 434-445.
- Dalal, S.S. 1992. Forestry-Past, present, future In: Status of Indian Forestry-Problem and perspectives. P.K.Khosala (ed.), ISTS, Solan: 16: 25.
- Das, R.B. and R.S. Paroda. 1980. Rational utilization of grazing resources for sustained primary and secondary productivity in Arid Zone. *Ann. Arid Zone*. 19: 407-412.
- Debroy, R., Das, R.B. and Bhati G.N. 1975. Studies on effect of intensity and interval defoliation on forage production of *Dichanthium annulatum* (Forsk) Stapf. *Ann. Arid Zone*, 14: 13-20.
- Dee, R.F., T.W. Box and E.D. Robertson. 1966. Influences of grass vegetation on water intake of Pullman silty clay loam. *J. Range Manag.* 19(2): 77-79.
- Dyrness, C.T. and C.T. Youngberg. 1966. Soil vegetation relationship within the ponderosa pine type in the central Oregon pumice region. *Ecology*, 47(1): 122-138.

- Eckert, Richard E. and John S. Spencer. 1987. Growth and reproduction of grasses heavily grazed under rest rotation management. *Range Management*. 40(2): 156-159.
- Ellis James E. and David M. Swift. 1988. Biomass Carrying capacity and Nutritional Dynamics. IIIrd International Rangeland Congress. 70 p.
- Ghosh, S.P. (ed.). 1991. Agroclimatic zone specific Research. ICAR, New Delhi: 539 p.
- Girija Vallabhan, P. and K. Krishnan. 1988. Improving the natural grassland in Western Ghats by reseeding with selected forage species. IIIrd International rangeland Congress (2): 354-357.
- Goering, H.K. and Van Soest P.J. 1970. Forage fibre analysis. Agric. Hand Book No. 379. USDA, Washington, D.C. p.20.
- Goodloc, S. 1969. Short duration grazing in Rhodesia. *J. Range Management*. 22 (6): 369-373.
- Gufa Oba. 1988. Survey of Riparian wood land community of the semi desert region of North-Western Kenya. IIIrd International Rangeland Congress (I) : 15 p.
- Gupta, A.K. and D.C. Joshi. 1984. Influence of grazing on the minerals content of different species. *Indian J. Anim. Sci.* 54: 270-274.
- Gupta, B. 1997. Grazing impacts on reducing sugar and starch content of grassland vegetation in Shimla. *Range Mgmt. & Agroforestry*. 18 (2): 103-112.
- Gupta, R.K. 1988. Ecology of high altitude rangelands of Western Himalaya for pasture management and soil conservation. IIIrd International Rangeland Congress (I) : 11p.

- Hanson, H.C. and E.D.Churchill. 1965. The plant community. Rein hold publ. Cor., New Delhi.
- Hare, M.A., D.O. Lantagne, P.G.Murphy and H. Checo. 1997. Structure and tree species composition in a sub tropical dry forest in the Dominican republic: Comparison with a dry forest in Puerto Rico. *Tropical Ecology*. 38(1): 1-17.
- Harsh, L.N. 1988. Comparison of continuous and deferred rotational grazing in arid and semi arid rangeland of Jadan , West Rajasthan, India. IIIrd International Rangelands Cong. (2) : 374-377p.
- Harsh, L.N. and M.D.Yadav. 1987. Management of *Sporobulus-Eleusine* grassland by grazing systems. Ind. *J. Range Mgmt.* 8(2): 67-72.
- Harsh, L.N., C.M. Verma and B.L.Jain. 1981. Relation between precipitation and forage production of *Cenchrus ciliaris* Linn. in arid region. *Ann.Arid Zone*. 20: 101-106.
- Hasan Badrul, R.K. Beniwal and J.S. Mann. 1988. Lopping management and fodder production suitability of fodder trees and shrubs of semi arid Rajasthan: IIIrd International Rangeland Congress (2): 530-531p.
- Hazara, C.R. 1995. Grasses and legumes for soil and water conservation in semi arid tropics of India. *J. Range Mgmt. & Agroforestry*. 16(2): 1-16.
- Hazell, D.B. 1967. Effect of grazing intensity on plant composition, vigour and production. *J. Range Manag.* 20(4): 249-252.
- Heitschmidt, R.K., S.L.Dowhower and J.W.Walker. 1987. 14 Vs 42 paddocks rotational grazing: Above ground biomass dynamics, forage production and harvest efficiency. *J. Range Manage.* 40: 216-223.

- Holmes, W. 1962. Grazing management for dairy cattle. *J. Brit. Grassl. Soc.* 17: 30-40.
- Horrell, C.R. and M.N.Court. 1965. Effect of the legume *Stylosanthes gracilis* on pasture yield at Serse, Uganda. *J. Brit. Grassl. Soc.* 20: 72-76.
- Hyder, D.N., R.E.Bement, E.E. Remenga and C.Terwilliger. 1966. Vegetation-soil and vegetation-grazing relations from frequency data. *J. Range manag.* 19(1): 11-16.
- Jain, S.K. 1988. Inventory of Indian Grasses- their diversity and Phytogeography. IIIrd International Congress (I) : 43 p.
- Jefferies, N.W. and R.W.Rice. Nutritive value of clipped and grazed range forage. *J. Range Manag.* 22(3): 192-196.
- Joshi, D.C. 1988. Status of minerals elements in different pasture species in arid condition. IIIrd International Rangeland Congress (I) : 17 p.
- Joshi, Mukesh. Effect of forage availability on grazing activity of cattle and goats. *Range Mgmt. & Agroforestry.* 16(2): 23-31.
- Joshi, S.P., Anurag Raizada and M.M.Srivastava. 1991. Biomass and net primary productivity under deferred grazing pattern in a Himalayan high altitude grassland. *Range Management & Agroforestry.* 12(1): 1-13.
- Kalmbacher, R.S., E.M.Hodges and F.G.Martin. 1980. Effect of plant height and cutting height on yield and quality of *Indigofera hirsuta*. *Trop. Grassld.* 14(1): 14-18.
- Kanodia, K.C. 1988. Impact of grazing on seasonal changes of structural and functional attributes of rangeland vegetation in Bundelkhand Region. IIIrd International Rangeland Congress (I): 177- 181 p.

- Kanodia, K.C. 1988. Production potential of tropical pastures under repeat defoliation management in India. IIIrd International Rangeland Congress (2) : 326-328 p.
- Kanodia, K.C. 1994. Evaluation of different pasture production systems as influenced by grazing animals in semi-arid tropics of India. In: P.Singh, P.S. Pathak and M.M. Roy (eds.) Agroforestry system for degraded rangelands. Vol. II: 572-578. Oxford & IBH Pub. Co., New Delhi.
- Kanodia, K.C. and P.Rai. 1981. Changes in forage yield and chemical composition of range grasses. *Annals of Arid Zone*. 20(4): 241-245.
- Kanodia, K.C., G.K.Dwivedi and D.Singh. Effect of fertilizer application on biomass production in *Sehima nervosum*. *Range Mgmt. & Agroforestry*. 14(1): 35-41.
- Katewa, S.S. and Y.D.Tiyagi. Productivity potential of grazing lands of Udaipur District (Rajsthan). *Range Mgmt. & Agroforestry*. 12(1): 53-59.
- Khokar, J.S. and Virendra Singh. 1988. Food Fuel and forage production potential of multipurpose trees. IIIrd International Congress (2): 537-539 p.
- Kumar, A. and M.C.Joshi. 1972. The effect of grazing on the structure and productivity of the vegetation near Pilani, Rajasthan, India. *J. Ecol.* 60: 665-674.
- Mann, H.S. and Vinod Shankar. 1978. Productivity of arid grazing land ecosystem. CAZRI, *Monograph* No. 19. Jodhpur. India.
- Manoharan, K, and K. Paliwal. 1988. Grazing and dry matter dynamics in a semi arid grassland community at Naga Malai, Eastern Ghats of Tamil Nadu. IIIrd International Rangeland Congress (I): 144-146p.

- Meenakshisundaravalli, V. and K. Paliwal. 1997. Dry matter production and Nitrogen dynamics in the semiarid grazing lands of Madurai, India. *Trop. Ecol.* 38(1): 81-86.
- Melkania, N.P. 1988. Floristic composition and life forms of vegetation in foot hill Zone of Central Himalaya. *Indian J. Range Mgmt.* 9: 15-27.
- Melkania, N.P. and J.P. Tandon. 1985. Environmental Regeneration in Himalaya: Concepts and strategies, In: J.S. Singh (ed.). 399-409 p. CHEA and Gyanodaya Prakashan, Nainital.
- Melkania, N.P. and J.P. Tandon. 1988. Management of rangelands in Himalaya: A regional study. 361-363 p. IIIrd International Rangeland Congress Abstract Vol. II RMSI, IGFRI, Jhansi, India.
- Mengel, K. And Kirkby, E.A. 1982. Principles of plant nutrition. International Potash institute, Berne. 655 p.
- Mertia, R.S. 1991. Pasture and animal productivity from grazing lands under rotational grazing system in semiarid regions of India. *Range Mgmt. & Agroforestry.* 12(2): 133-137.
- Mertia, R.S. 1992. Studies on improvement and utilization of rangelands of Jaisalmer region. CAZRI, Publication No. 8, Jodhpur, India.
- Mishra, L.P. and Bhatt, R.K. 1990. Light transmission, canopy temperature and productivity of grasses under silvipastoral system. In: Silvipastoral system in India (eds.) P.S. Pathak and Punjab Singh) RMSI, Jhansi: 179-182.

- Misra, M.K., P.C.Tripathi and S.P.Nayak. 1994. Effect of clipping on the biomass and primary productivity of a coastal grassland in Orissa. *Range Mgmt. & Agroforestry*. 15(1): 23-27.
- Mittal, J.P. 1988. Judicious utilization of desert range resources through raising sheep and goat. IIIrd International Rangeland Congress (2): 425-427 p.
- Mittal, J.P., Shiv Prasad, B.K. Mathur and A.K. Bawa. 1988. Performance of desert cattle on *Lasiurus sindicus* pasture. IIIrd Int. Rangeland Cong. (2): 450-451p.
- Mojumdar A.B. and A. Rakib. 1994. Evaluation of stylosanthes species for its nutritional composition at different stages of maturity. In: P. Singh, P.S. Pathak and M.M. Roy (eds.). *Agroforestry systems for degraded lands*. Vol. II.: 564-567. Oxford and IBH Pub. Co. Ltd., New Delhi.
- Negi, G.C.S., H.C.Rikhari and S.P.Singh. 1993. Height growth response of certain alpine meadow plants to clipping and grazing. *Range Mgmt. & Agroforestry*. 14(2): 93-101.
- Omar, Samira and Sameeha, Zaman. 1988. Current status of vegetation in Kuwait;s rangelands. IIIrd International Rangeland Congress (I) : 24 p.
- Odum, E.P. 1971. Development and evaluation of the ecosystem. *Fundamentals of Ecology*, W.B.Saunders, Company.Philadelphia. 291 p.
- Omaliko, C.P.E. 1984. Dung decomposition and its effects on the soil components of a tropical grassland ecosystem. *Tropical Ecol.* 25(2): 214-220.
- Oosting, H.J. 1958. The study of plant community. W.H.Freeman and Co. San Francisco. Page-367.

- Pandey, C.B. 1990. Species composition and standing crop of a Savanna in a dry tropical forest region of India. *Range Mgmt. & Agroforestry*. 11(1): 13-19.
- Pandey, T.N. 1977. Ph.D. Thesis, BHU, Varanasi.
- Pandit, B.R., K.Vallikadevi and T.S.Reddy. 1990. Productivity and herbage dynamics of a semiarid grassland. *Range Mgmt. & Agroforestry*. 11(1): 1-5.
- Pandit, B.R., S.Gopalan, V.Devi and P.A.Parekh. 1996. Species composition and life forms of the grazing land at Bhavnagar. *Range Mgmt. & Agroforestry*. 17(1): 1-6.
- Pandya, S.M. and V.K. Sidha. 1989. Nutrients dynamics in the arid and semi arid grazing land of Kutch (Gujrat). *I. Journal of Range Mgmt.* 10 : 81-90.
- Pandya, S.M. and V.K.Sidha. 1989. Seasonal variation in plant biomass and primary production in grazing lands of Kutch District. *Indian J. Range Mgmt.* 10(1): 15-32.
- Parthasarathy, N. and Pia Sethi. 1997. Trees and Liana species diversity and population structure in a tropical dry evergreen forest in South India. *Tropical Ecology* 38(1): 19-30.
- Patnayak, B.C., P.C. Mali and C.P. Shrivastava. 1988. Productivity and plane of nutrition of sheep and goats on protected rangeland in the North West Arid Zone of India. IIIrd International Rangeland Congress (2): 423-425p.
- Paulsamy, S., A.S.Lakshamanachary and S.Manian. 1987. Effect of over grazing on the phytosociology of a tropical grassland ecosystem. *Ind. J. Range Mgmt.* 8(2): 103-107.
- Pearson, G.A. 1930. Light and moisture in forestry. *Ecology*. 11: 139-144.

- Perevolotsky Avi and Yigal Hamov. 1988. The management of dense Mediterranean Maqui: The effect of cutting and goat grazing. IIIrd International Rangeland Congress (2): 342-345.
- Phillippi Dennis. 1998. Grazing management in the Northern great plains of North America. IIIrd International Rangelands Congress (2): 323-325.
- Pieper, Rex. D. 1968. Comparison of vegetation on grazed and ungrazed Pine-Juniper grassland sites in South Central New Mexico. *J. Range Manag.* 21(1): 51-53.
- Pinder, III, John E. 1975. Effect of species removal on an old field plant community. *Ecology.* 56(3): 747-751.
- Piper, C.S. 1966. Soil and plant analysis. Hans publication, Bombay, India : p.368.
- Poissonet, J.A. and W. Deiri. 1988. Effect of the variability of rains on vegetation in some representative experimental plots with three main plants association in the Syrian Badia. IIIrd International Congress (I) : 43p.
- Prajapati, M.C. 1970. Effect of different systems of grazing by cattle on *Lasiurus-Eleusine-Aristida* grassland in arid region of Rajasthan vis a vis animal production. *Annals of Arid Zone.* 9: 114-124.
- Prajapati, M.C., K.T.N.Nambiar, P.Bhaskara Rao and B.S.Thippannaver. 1975. Ecological studies on village grazing lands around Bellary. *Ann. Arid.Zone.* 14: 1-12.
- Premi, O.P. and B.R.Sood. 1999. Forage yield and seasonal distribution as influenced by the introduction of improved grass, legume and tree component. *Range Mgmt. & Agroforestry.* 20(2): 115-119.

- Raheja, P.C. 1965. Influences of climatic changes on the vegetation of the arid zone in India. *Ann. of Arid Zone*. 4: 64-73. ;
- Rai, P. 1988. Stylos as an inter crop in the tropical pasture of India. IIIrd International Rangeland Congress (2): 320-322 p.
- Rai, P. 1997. Impact of grazing on the plant composition and dominance of natural grassland and established silvipasture. *Annals of Arid Zone*. 36(2): 151-154.
- Rai, P. And N.C.Verma. 1995. Studies on evaluation of *Dichanthium annulatum* pasture with and without legume (*Stylosanthes hamata*) for Sheep production. *Range Mgmt. & Agroforestry*. 16(1): 61-64. ;
- Rai, P. and V.S.Upadhyaya. 1990. Performance of growing Mandya Sheep on natural *Sehima-Heteropogon* grassland. *Ann. of Arid Zone*. 29(2): 151-152.
- Rai, P. and V.S.Upadhyaya. 1993. Comparative feeding value of two tropical grass species for growing Sheep. *Range Mgmt. & Agroforestry*. 14(2): 135-138.
- Rai, P., K.C.Velayudhan, K.A.Shankarnarayan and K.C.Kanodia. 1981. Effect of Neem cake blended urea and its time of application on quantity and quality of *Sehima-Heteropogon* grassland at Jhansi. *Ann. of Arid Zone*. 20: 107-116. ;
- Raina, Pramila and D.C.Joshi. 1991. Influences of grazing on the soil fertility status of sown and natural pastures in arid region. *Ann. of Arid Zone*. 30(3): 197-201.
- Ram J., J.S. Singh and S.P. Singh. 1989. Plant biomass, species diversity and net primary production in a Central Himalayan high altitude grasslands. *J. of Ecology* 77: 456-468.

- Ramakrishana, Y.S. 1984. Forest microclimate and its importance in Agroforestry. In: Agroforestry in Arid and semiarid Zones (ed. K.A.Shankarnarayan) CAZRI, Jodhpur: 9-14.
- Rao, A.S., K.C.Singh, Y.S.Ramakrishna and R.S.Singh. 1993. Microclimate impact on the relative growth of *Cenchrus ciliaris* and *C. setigerus*. *Annals of Arid Zone*. 32(4): 245-250.
- Rauzi, F. and C.L.Hasson. 1966. Water intake and runoff as affected by intensity of grazing. *J. Range Manag.* 19(6): 354-356.
- Rosenberg, N.J. 1986. A primer on climate change. Discussion paper series. R.R. 86-04. Resources for the future, Washington, D.C.
- Rout S.K. and S.R.Gupta.1988. Biomass dynamics and nutrient composition of herbaceous layer in forest ecosystems of Momi Hills. IIIrd International Rangeland Congress (2): 545-547.
- Sah, V.K. and A.K.Saxena. 1990. Variation in structure, biomass and species diversity of grazing lands in Garhwal Himalaya. *Range Mgmt. & Agroforestry*. 11(2): 115-121.
- Samira Omar and Sameena Zaman. 1988. Current status of vegetation in Kuwait's Rangelands. IIIrd International Rangeland Congress (I) : 24 p.
- Sangakkara, U.R. 1988. Effect of rain fall on the growth of a tropical rangeland. IIIrd International Rangeland Congress (I): 82 p.
- Sangakkara, U.R. 1988. Importance of tropical rangeland- A case study in Sri Lanka. In: (eds.) Panjab Singh, Vinod Shankar and A.K. Srivastava. IIIrd International Rangeland Congress (2): 316-320.

- Sant, H.R. 1966. Grazing effects on grassland soils of Varanasi, India. *J. Range Manag.* 19(6): 362-367.
- Sant, H.R., and D.D. Pandey. 1988. Response of grazing to energy conserving efficiency of rangelands at Varanasi. IIIrd International Rangeland Congress (I) : 71p.
- Seth, C.M. 1996. Biomass fluctuation in Alpine pasture of Kashmir Himalaya. *Annals of Arid Zone.* 35(1) : 65-67.
- Shankar, V., K.C. Velayudhan and B.K. Trivedi. 1975. Diversity dominance, stability and net production in three communities of *Sehima-Dichanthium* cover. *Geobios* 2: 107-110.
- Shankarnarayan, K.A. 1977. Impact of over grazing on the grasslands. *Annals of Arid Zone.* 16: 349-359.
- Shankarnarayan, K.A. and P.M.Dabadghao. 1970. Ecological studies on the grassland of Jhansi U.P. *Ann. of Arid Zone.* 9: 54-70.
- Shankarnarayan, K.A., N.L. Kackar and R.S. Mertia (1981). Productivity of large herbivores- cattle and sheep. Productivity of Arid Grazing land Ecosystem. CAZRI, Monograph No.19.
- Shankarnarayan, K.A., P.M.Dabadghao, R.Kumar and P.Rai. 1977. Effect of defoliation management and manuring on dry matter yields and quality in *Sehima nervosum*, *C. ciliaris* and *C. setigerus*. *Ann. of Arid Zone.* 16: 441-454.
- Shankarnarayan, K.A., P.M.Dabadghao, V.S.Upadhyaya and P.Rai. 1975. Notes on NPK effects on *Sehima* grasslands. *Indian J. Agric. Sci.* 45: 383-384.

- Shankarnarayan, K.A., P.M.Dabaghao, V.S.Upadhyaya and P. Rai. 1976. Effects of fertilizers (N and P) on the net above ground community productivity in *Heteropogon-Iseilema-Sehima* community. *Tropical Ecology*. 17: 110-112.
- Sharitz, R.R. and J.F.McCormick. 1973. Population dynamics of two competing annual plant species. *Ecology*. 54(4): 723-740.
- Sharma, K. and J.L.Ogra. 1990. Influences of continuous grazing by goats and sheep under three tiers pasture on their performance and constituent vegetation. *Range Mgmt. & Agroforestry*. 11(1): 99-102.
- Sharma, K., N. Singh, A.N. Saini and J.L.Ogra. 1988. Influences of grazing preference on the nutritive value of ingested herbage for goats under 3-tier pasture. 449-461 p. IIIrd International Rangeland Congress. Abstract Vol. II. Range Management Society of India, IGFRI, Jhansi, India.
- Sharma, K.D., N.S. Vargani, H.P. Singh, D.N. Bohra, A.K. Kalla and P.K. Joshi. 1997. Evaluation of contour vegetative barriers as soil and water conservation measures in arid lands. *Annals of Arid Zone*. 36(2): 123- 127.
- Shukla, N.P. 1996. Water logging and fodder production. *J. Environmental Research*. 6(2): 59-62.
- Singh, I. P., M. Datta and S.K. Dhyani. 1994. The vertical distribution of fine root biomass of twelve tree species on the Tilla land of Tripura, India. In: P.Singh, P.S. Pathak and M.M. Roy (eds.) *Agroforestry System for degraded lands*. Vol.(I) : 339-342. Oxford & IBH Pub. Co. , New Delhi.
- Singh J.S. and R. Mishra. 1969.Diversity, dominance, stability and net production in grassland at Varanasi. *Canadian J. of Botany*. 47: 425-427.

- Singh P. and M.H.Shah. 1991. Improvement of temperate grassland through introduction of grass-legume mixture. *Range Mgmt. & Agroforestry*. 12(1): 37-42.
- Singh, B., H.N.Mathur and P.Joshi. 1980. Effect of shade on grassland production in the moist sub tropical region of North India. *Indian J. Forestry*. 3: 343-345.
- Singh, J.P. and Vinod Shankar. 1994. Performance of cattle grazing in a grass-legume cafeteria including forage shrubs and trees. In: P. Singh, P.S. Pathak and M.M. Roy (eds.). *Agroforestry systems for degraded lands*. Vol. II: 258-264. Oxford and IBH Pub. Co., New Delhi.
- Singh, P. 1988. Rangeland reconstruction and management for optimizing biomass production. In: P. Singh and P.S. Pathak (eds.). 20-37 pp. *Rangelands – Resource and Management*. RMSI, IGRI, Jhansi, India.
- Singh, Panjab. 1995. Range lands and their improvement in India. *Ann.of Arid Zone*. 34(3): 157-161.
- Singh, S.P., J. Ram and R.P. Singh. 1988. Forage production and utilization in Central Himalaya Rangelands. In: P. Singh (ed.). *Pasture and forage crops research*. 86-96p. RMSI, IGRI, Jhansi, India.
- Singh, U.N. and Anoop Srivastava. 1988. Grazing studies to determine carrying capacity of *Bothriochloa* Grassland community in Bundelkhand Region. IIIrd International Rangeland Congress (I): 73 p.
- Singh, U.P., R. Debroy and Sanjeev Gupta. 1997. Effect of legume component, *Clitoria ternatea*, on biomass and crude protein yield of different pasture grasses.
- Skerman, P.J. and Riveros, F. 1992. *Tropical Grasses*. FAO, Rome and Scientific publishers, Jodhpur: 832 p.

- Skerman, P.J., Cameron, D.G. and Riveros, F. 1992. Tropical forage legumes. FAO, Rome and Scientific publishers, Jodhpur: 328 P.
- Smoliak, S. 1968. Grazing studies on native range, crested wheat grass and Russian wild rye pastures. *J. Range Manag.* 21(1): 47-51.
- Sood, B.R. and V.K. Sharma. 1994. Effect of introduction of Velvet bean, Nitrogen and spacing on the production and quality of a natural grassland of Kangra Valley (H.P.). *Range Mgmt. & Agroforestry.* 15(2): 135-139.
- Stafford Smith, D.M. 1988. Managing grazing distribution to maximize production and minimize degradation in semi arid rangelands. IIIrd International Rangelands Congress (2): 332-334.
- Strogen, C.L., F.B. Turner and R. Castetter. 1979. Litter fall from shrubs in the Northern Mojeve desert. *Ecol.* 60: 891-900.
- Suijcar Tony and Scott Christianses. 1987. The influence of grazing pressure on rooting dynamics of Caucasian Blue stem. *J. Range Manag.* 40: 224-227.
- Tainton, N.M. 1974. Effect of different grazing rotations on pasture production. *J. Brit. Grassld. Soc.* 29: 191-202.
- Thompson, L.M. and Troeh, F.R. 1985. Soils and Soil Fertility. Tata Mc. Grew- Hill publishing Co. Ltd., New Delhi : 516 p.
- Tivedi, B.K. and J.N. Gupta. 1994. Impact of certain management practices on the vigour of range grasses. In: P. Singh, P.S. Pathak and M.M. Roy (eds.). Agroforestry systems for degraded lands. Vol. (2): 625-631. Oxford and IBH Pub. Co., New Delhi, India.

Trivedi, B.K. (1988). Effect of management practices on the quality of *S. nervosum* stapf. in the semi arid region. IIIrd International rangeland Congress (2): 352-353.

Trivedi, B.K. 1990. An approach for increasing herbage quality of range species –Use of controlled burning with or without grazing . Silvipastoral systems in India, Proceedings of a national workshop on” Silvipastoral approach for waste lands development “ held at IGFRI,Jhansi, 1990: 159-164.

Trivedi, B.K. 1994. Seasonal variation in composition of grassland communities in District of Jhansi. *Range Mgmt. & Agroforestry*. 15(2) :123-127.

Trivedi, B.K. 1997. Management strategies of *Sehima-Heteropogon* grasslands for forage production. *Range Mgmt. & Agroforestry*. 18(1): 1-10.

Trivedi, B.K. and S.K.Soam. 1998. Phytosociological studies and assessment of the condition class of grassland in Madhav National Park. *Range Mgmt. & Agroforestry*. 19(2): 114-120.

Trivedi, B.K., K.C. Kanodia and Vinod Shankar. 1981. Effect of burning and grazing on the vigour of range grasses of *Sehima-Dichanthium* cover. *Geobios* 8: 13-17.

Tyagi, R.K. 1997. Grassland and Fodder Atlas of Bundelkhand. Indian Grassland and Fodder Research Institute , Jhansi. 178 p.

Ullah, Wasi, A.K.Chakravarty, C.P.Mathur and N.S.Vangani. 1972. Effects of contour furrows and contour bunds on water conservation in grasslands of W. Rajasthan. *Ann. of Arid Zone*. 11: 169-182.

Undersomder, D.J. and C.N.Naylor. 1987. Influences of clipping frequencies on herbage yield and nutrient content of tall Wheat grass. *J. Range Manag.* 40: 31-35.

- Upadhyaya, V.S. and K.S.Ramchandra. 1990. Chemical composition and nutrient availability of some browse species of Bundelkhand region for goat and sheep production, Silvopastoral system in India. pp. 183-186.
- Upadhyaya, V.S. and P.Rai. 1988. Productivity of sheep grazing on semiarid grassland. IIIrd International Rangeland Congress (2): 416-419.
- Upadhyaya, V.S., P.M.Dabadghao and K.A. Shankarnarayan. 1971. Relative grazing value of principal species of *Sehima-Dichanthium* cover.pp.48. Annual report IGFRI, Jhansi.
- Vogel, W.G., Van Dyne, G.M. 1966. Vegetation responses to grazing management on a foot hill sheep range. *J. Range Manag.* 19(2): 80.
- Vossbrinck, C.R., D.C.Coleman and T.A.Wooley. 1979. Abiotic and biotic factors in litter decomposition in a semiarid grassland. *Ecol.* 60: 265-271.
- Wheeler, J.L. 1958. The effect of sheep extract and Nitrogen fertilizer on the botanical composition and production of a ley. *J. Brit. Grassld. Soc.* 13: 196-202.
- Yadav, B.P.S.,H.K.Gupta and J.J.Gupta. 1998. Growth patterns in goats on native pasture of North-Eastern India. *Range Mgmt. & Agroforestry.* 19(2): 133-138.

APPENDIX

LIST OF PLANT SPECIES FOUND DURING STUDY

<i>A. longifolius</i>	- <i>Alysicarpus longifolius</i> (Wight & Arn.)
<i>A. indica</i>	- <i>Azadirachta indica</i> (A. Juss.)
<i>A. tortilis</i>	- <i>Acacia tortilis</i> (Forsk)
<i>A. nilotica</i>	- <i>Acacia nilotica</i> (L)
<i>A. catechu</i>	- <i>Acacia catechu</i> (L.F.Willd)
<i>A. leucophloea</i>	- <i>Acacia leucophloea</i> (Roxb)
<i>A. scarabaeoides</i>	- <i>Atylosia scarabaeoides</i> (Benth)
<i>A. varia</i>	- <i>Apluda varia</i>
<i>B. ramosa</i>	- <i>Brachiaria ramosa</i> (L)
<i>B. stricta</i>	- <i>Borreria stricta</i>
<i>B. monosperma</i>	- <i>Butea monosperma</i> (Lamk.)
<i>C. ciliaris</i>	- <i>Cenchrus ciliaris</i> (L)
<i>C. setigerus</i>	- <i>Cenchrus setigerus</i> (Vahl)
<i>C. argentea</i>	- <i>Celosia argentea</i> (L)
<i>C. fulvus</i>	- <i>Chrysopogon fulvus</i> (Spreng)
<i>C. viscosa</i>	- <i>Cleome viscosa</i> (L)
<i>C. ternatea</i>	- <i>Clitoria ternatea</i> (L)
<i>C. fascicularis</i>	<i>Corchorus fascicularis</i> (Lamk)
<i>C. pumila</i>	- <i>Cassia pumila</i> (Lamk)
<i>C. procera</i>	- <i>Calotropis procera</i> (Willd)
<i>C. spinarum</i>	- <i>Carissa spinarum</i> (L)
<i>D. annulatum</i>	- <i>Dichanthium annulatum</i> (Forssk)
<i>D. adscendens</i>	- <i>Digitaria adscendens</i> (Willd)
<i>D. biflorus</i>	- <i>Dolichos biflorus</i> (Lamk)
<i>D. sissoo</i>	- <i>Dalbergia sissoo</i> (Roxb.)
<i>D. cinerea</i>	- <i>Dichrostachys cinerea</i> (L)
<i>E. pilosa</i>	- <i>Eragrostis pilosa</i> (Hochst)
<i>E. hirta</i>	- <i>Euphorbia hirta</i> (L)

<i>E. alsinoides</i>	- <i>Evolvulus alsinoides</i> (L)
<i>E. laevis</i>	- <i>Ehretia laevis</i> (Roxb.)
<i>F. indica</i>	- <i>Flacourtia indica</i> (Burm.f.)
<i>H. contortus</i>	- <i>Heteropogon contortus</i> (L)
<i>H.integrifolia</i>	- <i>Holoptelea integrifolia</i> (Roxb.)
<i>I. laxum</i>	- <i>Iseilema laxum</i> (Hock)
<i>I. astragalina</i>	- <i>Indigofera astragalina</i> (Buch-Ham)
<i>I. mauritiana</i>	- <i>Ipomoea mauritiana</i> (Jacq)
<i>L. aspera</i>	- <i>Leucas aspera</i> (Willd)
<i>L. leucocephala</i>	- <i>Leucaena leucocephala</i> (Lamk)
<i>L. camara</i>	- <i>Lantana camara</i> (L)
<i>M. atropurpureum</i>	- <i>Macroptilium atropurpureum</i> (DC) Urb
<i>M. rubicaulis</i>	- <i>Mimosa rubicaulis</i> (Lam)
<i>P. trilobatus</i>	- <i>Phaseolus trilobatus</i> (L)
<i>P. virgatus</i>	- <i>Phyllanthus virgatus</i> (Forst.f.)
<i>S. glauca</i>	- <i>Setaria glauca</i> (L)
<i>S. nervosum</i>	- <i>Sehima nervosum</i> (Rottl.)
<i>S. hamata</i>	- <i>Stylosanthes hamata</i> (L)
<i>S. cordifolia</i>	- <i>Sida cordifolia</i> (L)
<i>S. virosa</i>	- <i>Securinega virosa</i> (Roxb.)
<i>T. quadrivalvis</i>	- <i>Themeda quadrivalvis</i> (L)
<i>T. rhomboidea</i>	- <i>Triumfetta rhomboidea</i> (Jacq.)
<i>T. procumbens</i>	- <i>Tridax procumbens</i> (L)
<i>Z. nummularia</i>	- <i>Ziziphus nummularia</i> (Burm.f.)
<i>Z. xylopyra</i>	- <i>Zizyphus xylopyra</i> (Willd)